YAMAHA MOTOR CO., LTD.

YAMAHA SINGLE-AXIS ROBOT DRIVER

RD series

User's Manual

ENGLISH E

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Note to the user

Our sincere thanks for purchasing this "YAMAHA single-axis robot driver RD series".
This user's manual describes handling and maintenance of the RD series. Read this manual thoroughly before using the RD series. Keep this manual handy so that the operator or maintenance personnel can easily refer to it when needed.
Before starting installation, operation, maintenance or inspection, read this manual carefully to understand RD series functions and comply with its safety information, precautions, and operating and handling instructions.
Always use the RD series within the operation range specified in this manual.
Perform correct inspection and maintenance to prevent possible problems.
When using optional products for this robot driver also be sure to carefully read their instruction manuals.
Please make sure this user's manual and option product manuals are delivered to the end user.

About this manual

- The contents of this manual are subject to change without prior notice.
- Carefully keep this manual because it will not be reissued.
- This manual must not be reproduced or reprinted in part or in whole without our permission.
- Every effort was made to ensure that this manual is accurate and complete. However, please contact us if you notice any errors, omissions or dubious points.

Please note that we accept no responsibility for any results that might occur from use of this manual or the unit described in it.

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Chapter 1 Safety precautions

To use this unit correctly and safely, always read this manual and all other attached documents carefully before use. Use this unit only after you are thoroughly familiar with its features and functions, safety information and precautions.

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To use this unit correctly and safely, always read this manual and all other attached documents carefully before use. Use this unit only after you are thoroughly familiar with its features and functions, safety information and precautions.

This manual classifies safety caution items into the following alert levels, using the signal words "DANGER" and "CAUTION".

DANGER

INDICATES AN IMMINENTLY HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, WILL RESULT IN DEATH OR SERIOUS INJURY.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury or damage to the equipment or software.

Note that some items described with "CAUTION" might lead to serious results depending on the situation. In any case, always observe the above instructions and precautions since they provide important safety information.
After reading this manual, always store it where the operator can easily refer to it any time when needed.

Symbols used to indicate a prohibited or mandatory action are explained below.

: Indicates a prohibited action. For example, indicates "Open flames prohibited

: Indicates a mandatory action. For example, indicates "Must be electrically grounded.

1.1 Precautions for use

DANGER

IMPROPER HANDLING MAY CAUSE ELECTRICAL SHOCK OR FIRE. ALWAYS OBSERVE THE FOLLOWING PRECAUTIONS.

1. **NEVER TOUCH ANY PART INSIDE THE ROBOT DRIVER.**
   TOUCHING PARTS MAY CAUSE ELECTRICAL SHOCK OR FIRE.
2. **ALWAYS GROUND THE GROUND TERMINAL ON THE ROBOT DRIVER AND ROBOT.**
   FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK.
3. **BEFORE MAKING WIRING CONNECTIONS OR INSPECTION, WAIT AT LEAST 10 MINUTES AFTER TURNING POWER OFF AND MAKE SURE THE CHARGE LAMP ON THE FRONT PANEL IS OFF.**
   FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK.
4. **DO NOT DAMAGE THE CABLES OR APPLY EXCESSIVE STRESS TO THEM. DO NOT PLACE HEAVY OBJECTS ON THE CABLES OR CRUSH THEM.**
   USING A DAMAGED CABLE MAY CAUSE ELECTRICAL SHOCK.
5. **NEVER TOUCH A MOVING PART OF THE ROBOT DURING OPERATION.**
   DOING SO MAY CAUSE INJURY.

CAUTION

1. Use only the specified robot and controller combination.
   Using the wrong combination may cause fire or malfunction.
2. Never use this unit in locations subject to water, grinding fluid mist, corrosive gases, explosive gases or salt damage. Do not use near inflammable objects or materials.
   Doing so may cause fire, malfunction or accidents.
3. The robot driver, robot and peripheral equipment may become hot during operation. Be careful not to touch them.
   Touching them may cause burns.
4. The robot driver's heat-sink fins, regenerative resistor, and robot may become hot when power is being supplied or shortly after power is turned off, so do not touch them.
   Touching them may cause burns.
5. Allow at least a 5-minute time interval between power on and off.
   Failure to do so may cause fire.
6. Install a leakage breaker on the power supply side of the robot driver.
   Failure to do so may cause fire.
7. Use a power line, leakage breakers and electromagnetic contacts that meet the required specifications (ratings).
   Failure to do so may cause fire.
8. Do not start/stop operation by turning on or off the electromagnetic contact installed on the power supply side of the robot driver.
   Doing so may cause fire.

1.2 Storage

PROHIBITED

DO NOT STORE THE UNIT IN LOCATIONS EXPOSED TO RAIN, WATER DROPLETS, GRINDING FLUID MIST OR HARMFUL GASES OR LIQUIDS.

MANDATORY

1. STORE THE UNIT IN LOCATIONS NOT EXPOSED TO DIRECT SUNLIGHT AND WITHIN THE SPECIFIED HUMIDITY AND TEMPERATURE RANGE (–10 TO +70°C, 20 TO 90% RH WITHOUT CONDENSATION).
2. CONSULT WITH OUR COMPANY IF YOU HAVE STORED THE UNIT OVER AN EXTENDED PERIOD OF TIME.

1.3 Carrying

CAUTION

1. Do not carry the robot driver by the cables.
   Doing so may cause malfunction or injury.
2. Do not carry the unit by the top cover or by the main circuit terminal block cover.
   Doing so may cause the unit to fall resulting in injury.

MANDATORY

LOAD THE UNITS CORRECTLY AS INDICATED. STACKING TOO MANY UNITS MAY CAUSE THEM TO FALL OVER.

1.4 Installation

CAUTION

1. Do not step or stand on the unit. Do not place heavy objects on the unit.
   Doing so may cause injury.
2. Do not block the air intake and exhaust vents. Do not allow foreign matter or debris to penetrate inside.
   Doing so may cause fire.
3. Always use the correct method to install the unit.
   The unit may malfunction if not properly installed.
4. Install the robot driver on a straight, vertical wall not subject to vibration.
   The unit may fall and injure someone if not properly installed.
5. Install the unit on a surface made of incombustible materials such as metal.
   Failure to do so may cause fire.
6. Install the unit at a place strong enough to support the weight of the unit.
   The unit may fall and injure someone if not properly installed.
7. Tighten the screws to the specified torque. Make sure that all screws are securely fastened before operation.
   The unit may fall and injure someone if not properly installed.
8. Provide the specified clearance between the robot driver and the inner surface of the control panel or any other unit.
   Failure to do so may cause malfunction.
9. Do not allow foreign matter such as cut wire fragments, welding debris, iron waste or similar items to penetrate inside.
   Doing so may cause fire.
10. Avoid applying strong shock to the unit to prevent malfunction.
11. Do not install the unit if any part is damaged or missing.
    Doing so may cause fire or injury.

1.5 Wiring

DANGER

1. WIRING WORK SHOULD BE CARRIED OUT BY QUALIFIED ELECTRICIANS.
   IMPROPER WIRING MAY CAUSE ELECTRICAL SHOCK OR FIRE.
2. ALWAYS FIRST INSTALL THE UNIT BEFORE CARRYING OUT WIRING.
   FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK OR INJURY.
3. MAKE SURE THE POWER IS OFF BEFORE CARRYING OUT WIRING.
   FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK OR FIRE.
4. BE SURE TO CONNECT THE ROBOT DRIVER'S GROUND TERMINAL TO THE GROUNDING POINT (CLASS D: 100 OHMS OR LESS).
   FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK OR FIRE.

CAUTION

1. Make sure that wiring connections are correct.
   Wrong connections may cause abnormal robot motion resulting in injury.
2. Cables connecting to the robot driver should be securely fastened near the robot driver so that no tensile stress is applied to the cables.
   Stress on the cables may lead to malfunction.

1.6 Control and operation

CAUTION

1. To prevent unstable or erratic operation never make drastic adjustments to the unit. Doing so may cause injury.
2. Install a safety circuit that actuates an electromagnetic contactor to cut off the main circuit power supply in case of an alarm.
   If an alarm has occurred, eliminate the cause of the alarm and ensure safety. Then reset the alarm and restart the operation.
   Failure to do so may cause injury.
3. If a momentary power outage occurs and power is restored, the unit might suddenly restart so do not approach the machine at that time. (Design the machine so that personal safety is ensured even if it suddenly restarts.)
   Failure to do so may cause injury.
4. Make sure that the AC power specifications match the product power specifications.
   Using the wrong power specifications may cause injury.
5. While power is being supplied, do not touch any parts inside the robot driver or its terminals.
   Also, do not check the signals or attach/detach the cables.
   Doing so may cause electrical shock or injury.
6. While power is being supplied, do not touch any terminals on the robot driver even if the robot is stopped.
   Doing so may cause electrical shock or fire.
7. When moving the robot for debugging the user program, configure a control circuit that turns off the servo ON terminal in cases where an emergency stop is required.
   Failure to do so may cause injury or damage the machine.

MANDATORY

INSTALL AN EXTERNAL EMERGENCY STOP CIRCUIT SO THAT YOU CAN IMMEDIATELY STOP OPERATION AND SHUT OFF POWER WHENEVER NEEDED.

1.7 Maintenance and inspection

DANGER

AFTER TURNING POWER OFF, WAIT AT LEAST 10 MINUTES BEFORE STARTING MAINTENANCE AND MAKE SURE THE CHARGE LAMP ON THE DIGITAL OPERATOR PANEL IS OFF.
FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK.

CAUTION

The capacitance of the capacitor on the power supply line drops due to deterioration. Replacing the capacitor based on its service life curve is recommended in order to prevent secondary damage resulting from capacitor failure. (See Chapter 7, "Maintenance and inspection", of this manual.)
Using a deteriorated or defective capacitor may cause malfunction.

PROHIBITED

DO NOT ATTEMPT TO DISASSEMBLE OR REPAIR THE UNIT OR REPLACE ANY PARTS OF THE UNIT. ONLY QUALIFIED SERVICE PERSONNEL ARE ALLOWED TO DO REPAIR WORK.

Chapter 2 Before using the unit

This chapter explains what you need to check after receiving the product you purchased as well as the warranty and the product part names.

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2.1 Inspection after unpacking

2.1.1 Checking the product

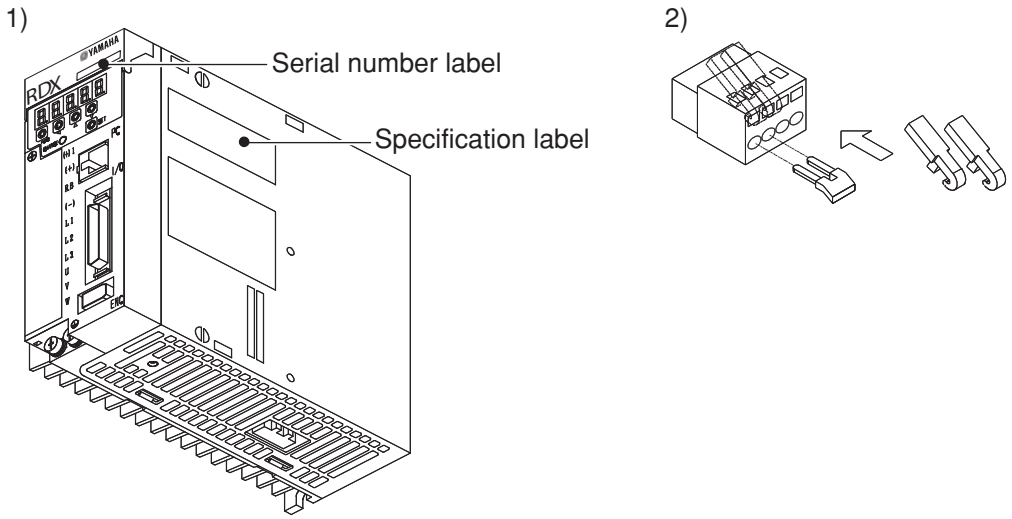
After unpacking, take out the robot driver and check the following items.
If you find or suspect any damage to the product please contact our sales office or sales representative.

(1) Make sure that there is no damage, missing parts or dents/scratches on the product body.

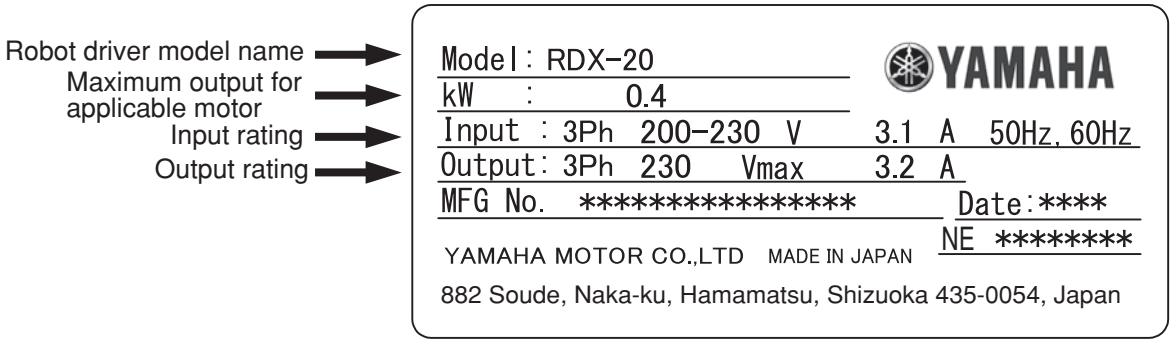
(2) After unpacking, make sure that the package contains the following items.

Item	Qty	Note
1) Robot driver	1	
2) Control power supply connector	1	Supplied with a wire inserter tool and B1-B2 shorting bar.
3) Connector plug	1	For detailed information, refer to 3.2.4, "Input/output signal wiring", in Chapter 3.
4) Connector cover non-shielded shell kit	1	

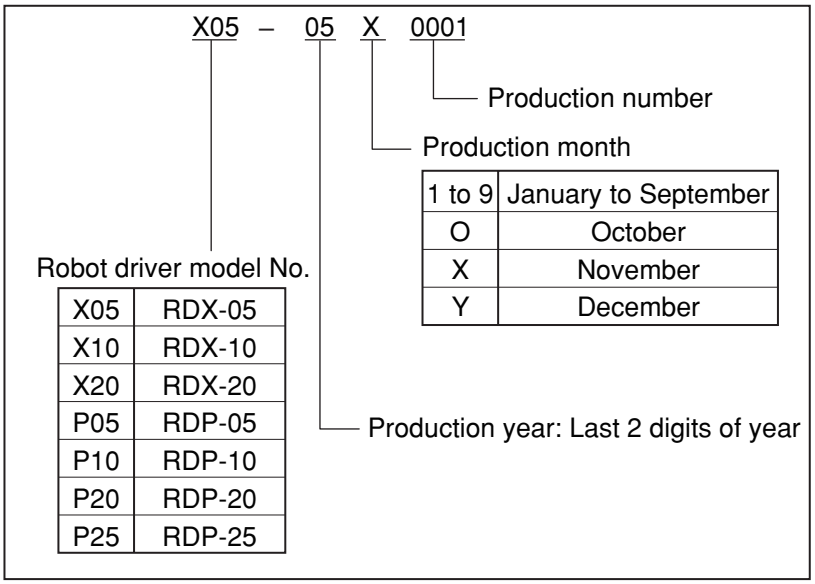
(3) Check the specification label to find whether the product is the same item as ordered.



Specification label position



Details on specification label



Details on serial number label

2.1.2 User's manual

This user's manual describes how to use the YAMAHA single-axis robot driver RD series. Before using the RD series, read this manual thoroughly in order to handle and operate it correctly. Store this manual carefully even after reading it.

2.2 Product inquiries and warranty

2.2.1 Notes when making an inquiry

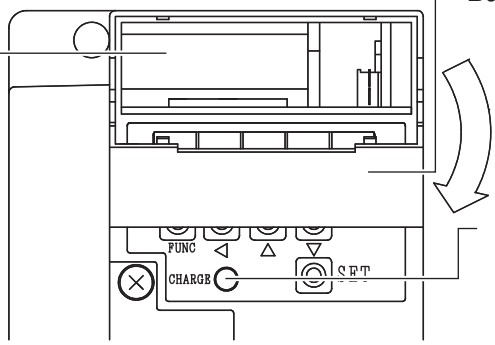
If you need to inquire about possible product damage, failures or points that are unclear, then please contact us with the following information.

(1)Robot driver model
(2)Production number
(3)Date of purchase
(4)Details of your inquiry
- Damaged section and condition, etc.
- Dubious point and description, etc.

2.2.2 Warranty

For information on the product warranty, please contact your local agent where you purchased your product.

2.3 External view and part names



Battery housing cover

Battery holder
Not used.

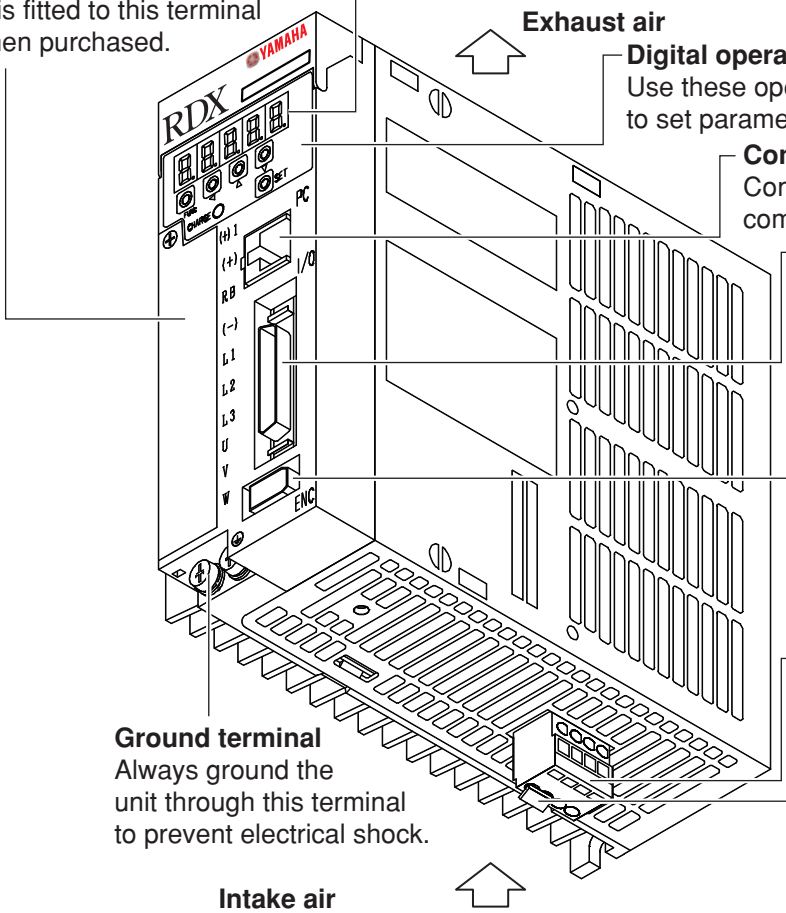
Charge lamp
Lights up when the main power supply is turned on. This lamp remains lit as long as the main circuit capacitor retains a charge after the power supply is turned off.
Do not touch the robot driver while the lamp is lit.

Main circuit terminal block (TM1)
Terminals for connecting to the main circuit power supply, external regenerative resistor, and motor power cable.
A cover is fitted to this terminal block when purchased.

Display panel
This is a 5-digit 7-segment LED display used as the operation monitor, parameter display and trip (alarm) display.

Exhaust air

Digital operator
Use these operator keys to set parameters.



Computer connector (PC)
Connects to a PC (personal computer) for data transfer.

Input/output signal connector (I/O)
Connector for command input signals, programmable controller input signals, and origin sensor signals.

Position sensor connector (ENC)
Connects to the linear motor position sensor or resolver.

Control power supply connector (TM2)
Connects to the control power supply.

B1-B2 shorting bar
Always connect this shorting bar when using an internal braking resistor (RD*-20 and RDP-25). (RD*-05 and RD*-10 have no internal braking resistor.)

Ground terminal
Always ground the unit through this terminal to prevent electrical shock.

Intake air (Natural air convection)

2.4 Robot driver and robot combination

The table below shows applicable combinations of robot drivers and robots.

Robot driver name	Model No.	Applicable robots
RDP (For PHASER series)	RDP-05	MR12, MR16
	RDP-10	MR16H, MR25, MF7
	RDP-20	MR20, MF15, MF20, MF30, MF50
	RDP-25	MF75
RDX (For FLIP-X series)	RDX-05	T4H, T5H, T6, T7, T9, F8, F8L, F8LH, F10, F14, B10, B14, R5, R10, C4H, C5H, C6, C8, C8L, C8LH, C10, C14
	RDX-10	T9H, F14H, B14H, R20, C14H
	RDX-20	F17, F17L, F20, F20N, N15, N18, C17, C17L, C20

Note: Parameters are adjusted at the factory prior to shipping so that the robot driver operates to control the target robot. Please contact us if you want to change the target robot model after shipping.

MEMO

Chapter 3 Installation and wiring

This chapter explains how to install the robot driver, as well as how to connect wiring to the main circuit and input/output signals. Typical connection examples are shown.

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3.1 Installation

CAUTION

1. Do not step or stand on the unit. Do not place heavy objects on the unit.
   Doing so may cause injury.
2. Do not block the air intake and exhaust vents. Do not allow foreign matter or debris to penetrate inside.
   Doing so may cause fire.
3. Always use the correct method to install the unit.
   The unit may malfunction if not properly installed.
4. Install the robot driver on a perpendicular wall not subject to vibration.
   The unit may fall and injure someone if not properly installed.
5. Install the unit on a surface made of incombustible materials such as metal.
   Failure to do so may cause fire.
6. Install the unit at a place strong enough to support the weight of the unit.
   The unit may fall and injure someone if not properly installed.
7. Tighten the screws to the specified torque. Make sure that all screws are securely fastened before operation.
   The unit may fall and injure someone if not properly installed.

Screw size	Tightening torque (N•m)	Note
M3	0.6 to 0.9	Mounting screws for robot driver and peripheral devices
M4	1.5 to 2.1	
M5	2.8 to 3.9	
M6	4.1 to 5.3	
M8	13.9 to 20.0	

8. Provide the specified clearance between the robot driver and the inner surface of the control panel or any other unit.
   Failure to do so may cause malfunction.
9. Do not allow foreign matter such as cut wire fragments, welding debris, iron waste or similar items to penetrate inside.
   Doing so may cause fire.
10. Avoid applying strong shock to the unit to prevent malfunction.
11. Do not install the unit if any part is damaged or missing.
    Doing so may cause fire or injury.

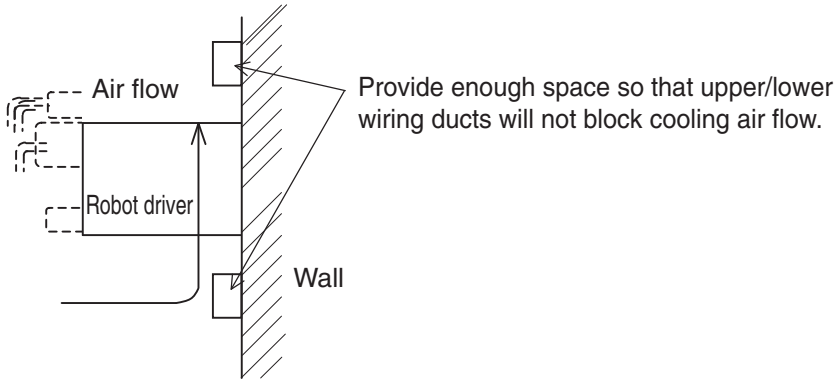
3.1.1 Precautions during installation

(1)Precautions when carrying the unit

The robot driver uses plastic parts. Handle it carefully to avoid damage to the plastic parts.
Take special care not to carry the unit in such a way that force is applied only to the front cover or terminal block cover. Otherwise you might drop the unit.
Do not install and operate the unit if any part is damaged or missing.

(2)Install the unit on an incombustible (metal) surface.

The robot driver becomes hot during operation. To prevent fire always install it on an incombustible, straight vertical metal wall.
Also provide enough space around the unit. If there is any heat generating device (braking resistor, electric reactor, etc.), keep the unit a sufficient distance away from it.



(3)Ambient temperature precautions

The ambient temperature in the installation place should not exceed the allowable operating temperature range (0 to 40˚C) specified in the standard specifications.
Measure the ambient temperature at a position about 50mm away from the lower center of the robot driver body, and make sure that it is within the allowable operating temperature range.
Operating the robot driver at a temperature exceeding the allowable range may shorten its service life (especially, capacitor life) or damage the internal components.

(4)Do not install the unit in locations subject to high temperatures and high humidity where condensation tends to occur.

Always operate the robot driver within the allowable operating humidity range (20 to 90% RH) specified in the standard specifications. In particular, operate it in locations free from condensation.
If water droplets formed inside the robot driver due to condensation, this might cause short-circuits between electronic components that result in malfunction.
Avoid installing the unit in locations exposed to direct sunlight.

(5)Installation environment precautions

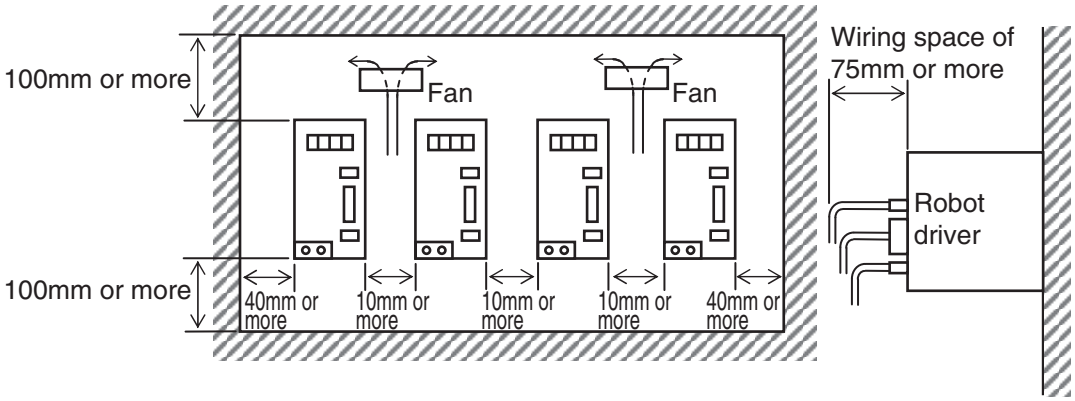
Avoid installing the unit in locations subject to dust, corrosive gases, explosive gases, combustible gases, grinding lubricant mist or salt damage. Dust or debris penetrating the unit may cause malfunction.
If the unit must be used in very dusty place, house it in a sealed dust-proof box.

(6)Installation method and direction precautions

Install the robot driver on a vertical surface capable of supporting the weight. Secure the robot driver firmly by screws or bolts.
If the robot driver is not installed vertically on the wall surface, the cooling capacity may degrade causing a trip or alarm and/or damaging the internal components.
For mounting hole locations, refer to 8.2, "Robot driver dimensions and mounting holes".

(7)Precautions when housing robot drivers in a box

When housing multiple robot drivers in a box and using ventilation fans, attach the fans as shown below in order to ensure a uniform temperature around each robot driver.



Install the robot drivers 40mm or more away from the inner side walls of the box and 100mm or more away from the inner top/bottom walls of the box. Allow a clearance of 10mm or more between adjacent robot drivers.

3.2 Wiring

DANGER

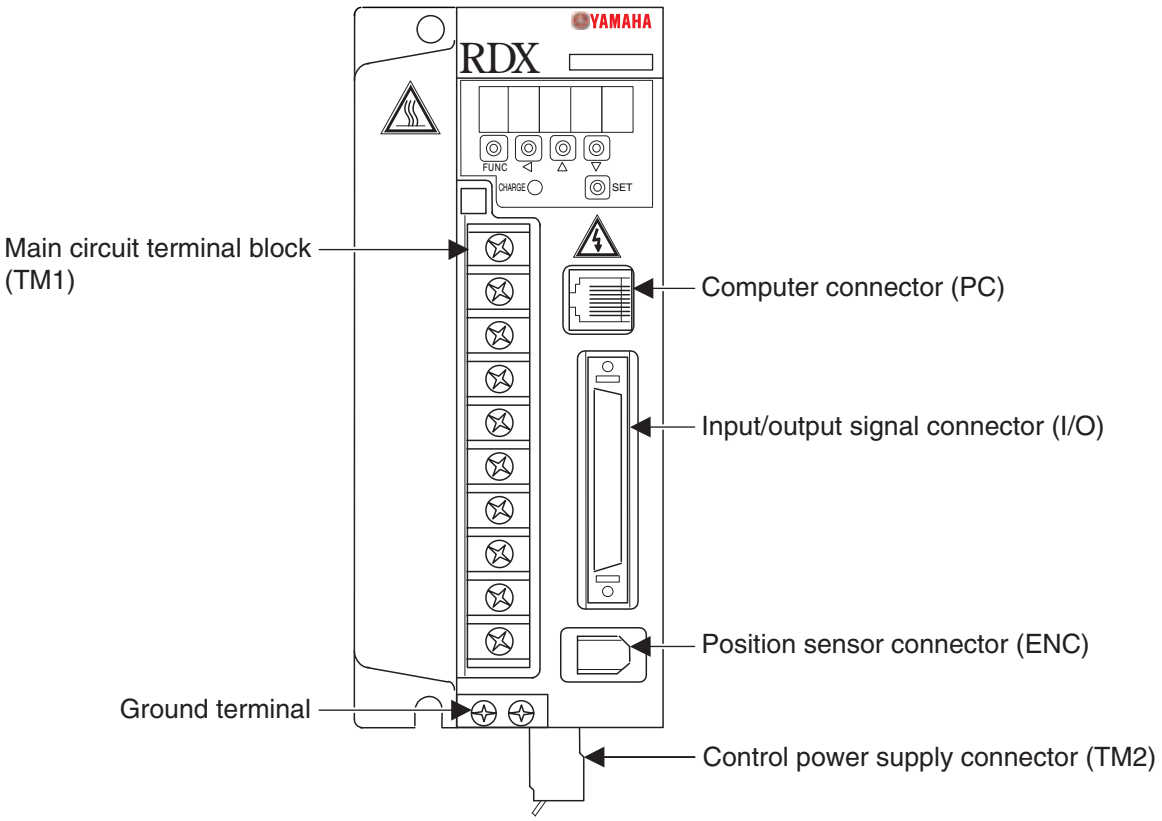
1. WIRING WORK SHOULD BE CARRIED OUT BY QUALIFIED ELECTRICIANS. IMPROPER WIRING MAY CAUSE ELECTRICAL SHOCK OR FIRE.
2. ALWAYS FIRST INSTALL THE UNIT BEFORE CARRYING OUT WIRING. FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK OR INJURY.
3. MAKE SURE THE POWER IS OFF BEFORE CARRYING OUT WIRING. FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK OR FIRE.

CAUTION

1. Make sure that wiring connections are correct. Wrong connections may cause abnormal robot motion resulting in injury.
2. Cables connecting to the robot driver should be securely fastened near the robot driver so that no tensile stress is applied to the cables. Stress on the cables may lead to malfunction.

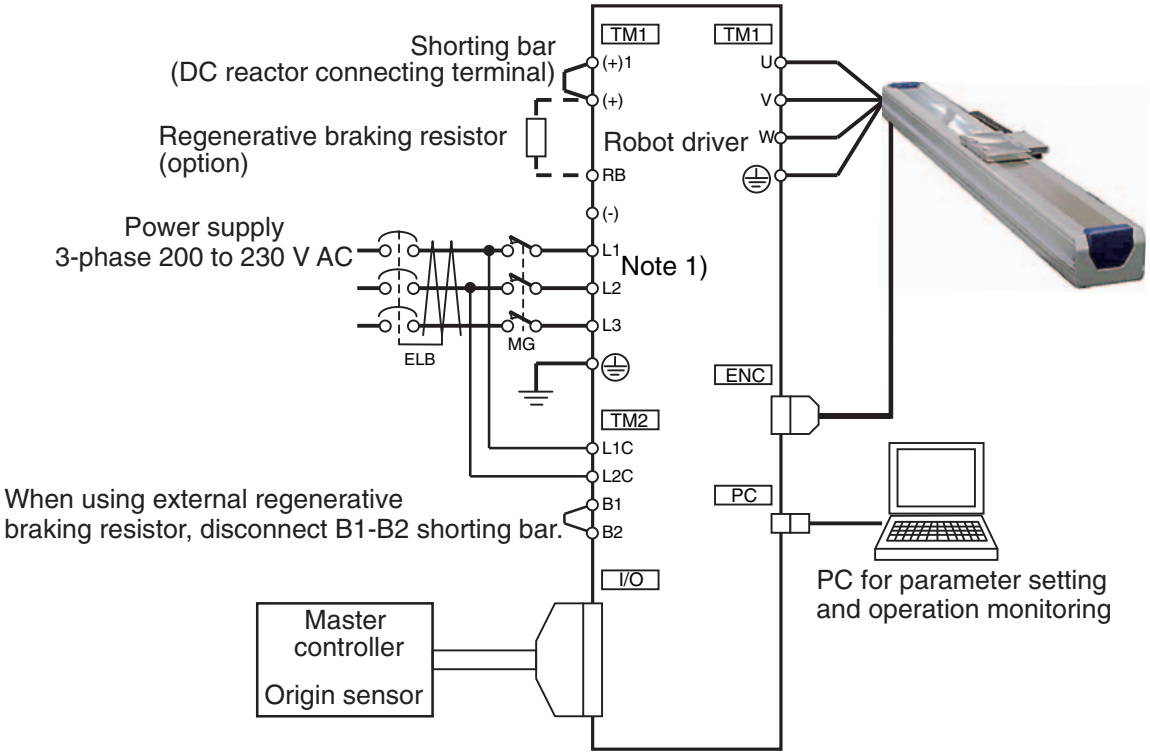
3.2.1 Terminal block and connectors

The terminal block and connectors on the robot driver are shown below.



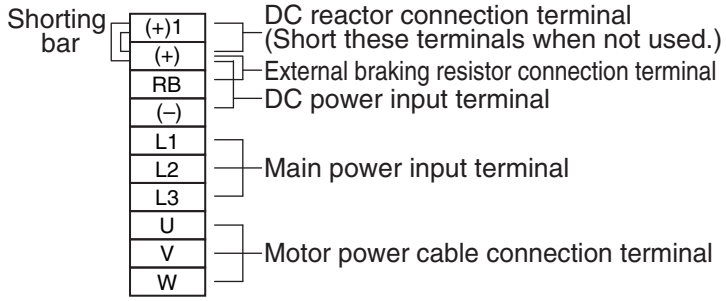
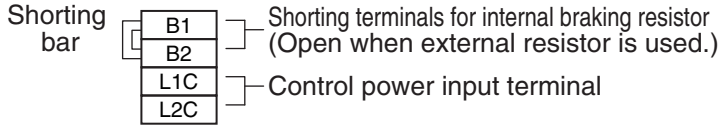
3.2.2 Main circuit wiring

(1)Terminal connection diagram



Note 1: Regenerative braking resistor is built in RD*-20 and RDP-25 robot drivers.
(Not built into RD*-05 and RD*-10 robot drivers.)

(2)Terminal assignment

Terminal block connector	Terminal assignment	Terminal screw size	Terminal width (mm)
Main circuit terminal block (TM1)		M4	8.1
Ground terminal		M4	–
Control power connector (TM2)	 Note: Diagram is shown as viewed from bottom of robot driver.		Applicable wire size: 1.25 to 2.0 mm^2

CAUTION

1. **Unplug the control power supply connector from the robot driver before wiring.**
   Failure to do so may damage the robot driver.
2. **When inserting the wires into the terminal, be careful not to bring the core wire braid into contact with other conductive parts.**
   Failure to do so may damage the robot driver.
3. **If for some reason the inserted portion of the wire is frayed, cut off that frayed portion and restrip the wire. Then reconnect the wire securely.**
   Using frayed wire may damage the robot driver.

(3)Wiring precautions

Before starting wiring, make sure that the charge lamp is completely off. Use caution because the capacitor might still be charged with high voltage creating a hazardous condition. About 10 minutes or more after power-off use a voltmeter or similar instrument to check that no voltage remains across the (+) and (–) terminals on the main circuit terminal block, and then start wiring.

1) Main power input terminals (L1, L2, L3)

- Use an earth leakage breaker (ELB) to protect circuit (wiring) between the power supply and main power input terminals (L1, L2, or L3).
- Some earth leakage breakers may malfunction due to effects from higher harmonics, so use one having large current sensitivity at high frequencies.
- Connect an electromagnetic contactor that shuts off the power supply to the robot driver to prevent a failure or accident from spreading when the robot driver's protective function is activated.
- Do not attempt to start or stop the robot driver by turning on or off each electromagnetic contactor provided on the primary side and secondary side of the robot driver.
- Do not use the robot driver in an open-phase condition.
- Any of the following conditions may damage the converter module so use caution.
  The power supply voltage imbalance is 3% or more.
  The power supply capacity is 10 times larger than the robot driver capacity or 500kVA or more.
  A sudden fluctuation occurs in the power supply.
  (Example) Multiple robot drivers are connected to each other by a short bus line.
  In any case, connecting a DC reactor (DCL) is recommended.
- When turning power on or off allow at least a 5-minute time interval between power on and off in order to avoid damage to the robot driver.

2) Motor cable connection terminals (U, V, W)

- To minimize voltage drops, use thicker wires than normally used.

3) DC reactor (DCL) connection terminals ((+)1, (+))

- These terminals are used to connect a DC reactor DCL for power factor improvement.

  A shorting bar is connected across terminals (+)1 and (+) at the factory prior to shipping. When connecting a DC reactor to these terminals, disconnect the shorting bar. When not using a DC reactor, leave the shorting bar connected.

4) External braking resistor connection terminals ((+), RB))

- A regenerative braking circuit and braking resistor are built into the robot drivers (RD*-20 and RDP-25). To enhance braking capacity, you can connect an optional external braking resistor to these terminals. In this case, disconnect the shorting bar from the internal braking resistor terminals (B1, B2). The wiring length should be 5 meters or less. Wire by twisting the two wires together.
- Install a resistor whose resistance is higher than the R_{BRmin} specified in the following table.
  Installing a resistor whose resistance is lower than specified will damage the regenerative braking circuit.

Robot driver model	Built-in braking resistor R_{BR}	Minimum resistance R_{BRmin}
RD*-05	None	100Ω
RD*-10	None	100Ω
RD*-20	30W 75Ω (10W, 0.5%)	50Ω
RDP-25	50W 50Ω (15W, 0.5%)	40Ω

Note: The power (wattage) of built-in braking resistor R_{BR} is the nominal value. The values in parentheses indicate the available average power (W) and allowable duty ratio (%).

For details on external braking resistors, refer to 10.1, "Options".

5) DC power input terminals ((+), (–))

- Connect a DC power supply to these terminals when supplying DC power from an external converter. Use a DC power supply that provides 270 to 310V DC and has sufficient capacity.
- When supplying DC power, do not connect anything to the main power input terminals (L1, L2, L3).
- When supplying DC power, set the "DC bus power supply" (FA-07) parameter to "Pn". If this is not set, an open-phase or momentary power failure will be mistakenly detected.

6) Control power input terminals (L1C, L2C)

- In addition to the main circuit power supply, this robot driver requires a control power supply. Be sure to connect a single-phase AC power supply to these control power input terminals (L1C, L2C). Also use a circuit (wiring) protection breaker or earth leakage breaker along with the control power supply. Some earth leakage breakers may malfunction due to effects from higher harmonics, so use one having large current sensitivity at high frequencies. When turning power on or off, allow at least a 5-minute time interval between power on and off. Turning power on or off at shorter time intervals may damage the robot driver.

7) Shorting terminals for internal braking resistor (B1, B2)

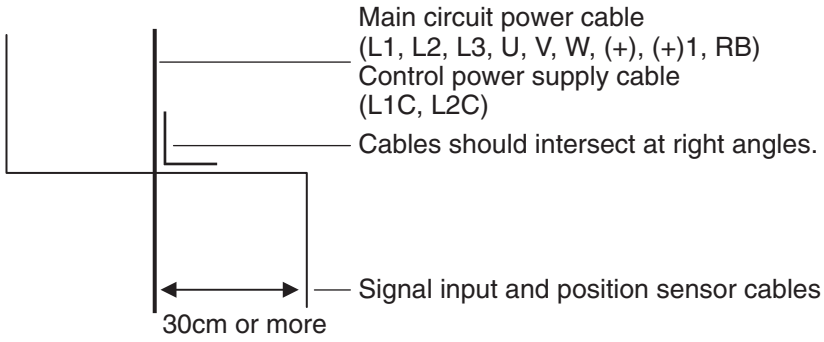
- When using the internal braking resistor, short the terminals B1 and B2 together. When using an external braking resistor, disconnect the shorting bar from these terminals. (The RD*-20 and RDP-25 have an internal braking resistor.)

8) Ground terminals (⏚)

- To prevent electrical shock, be sure to ground the robot driver and the robot body.
- Connect the ground terminals to a proper grounding point (Class D: 100 ohms or less).
- The ground wire should be thicker than those generally used and as short as possible.

Note 1: To connect wiring to the terminal block, use crimp terminals that match the terminal width. If the crimp terminal width is too wide, then a bad connection or misconnection may result.

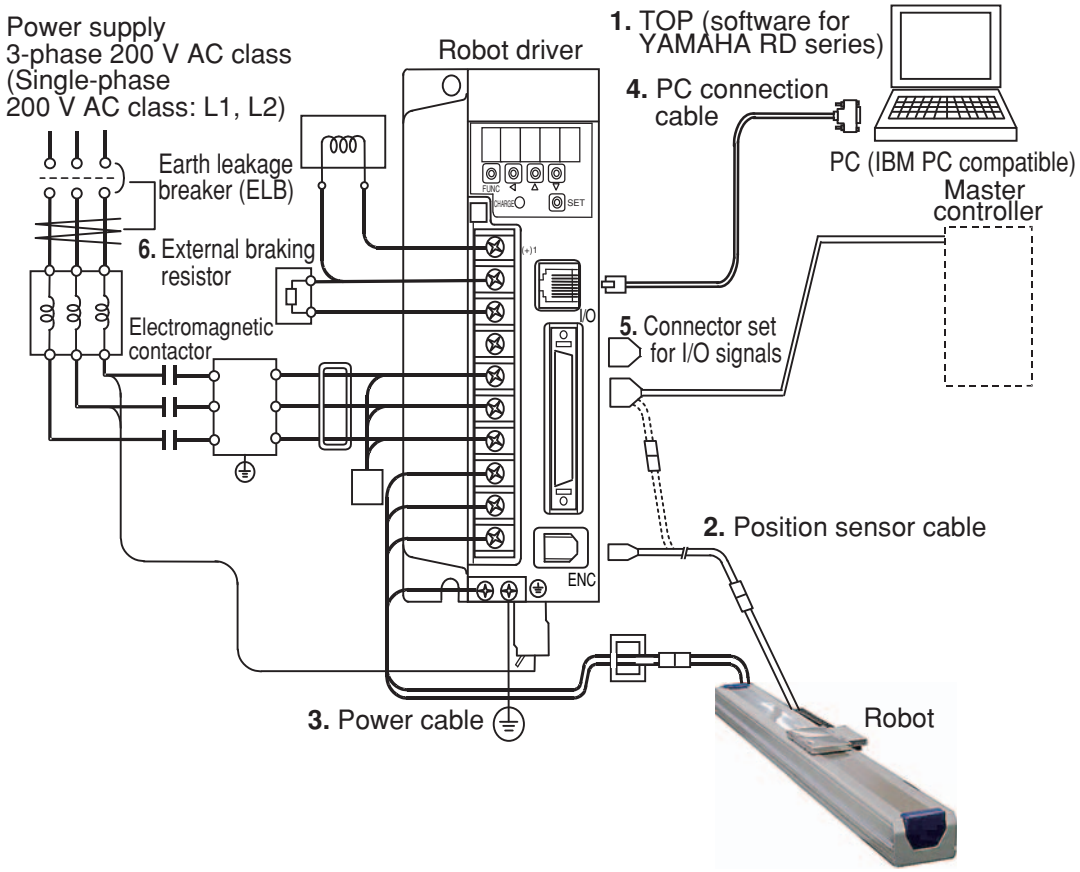
Note 2: Separate the robot driver signal input cable and position sensor cable at least 30cm from the main circuit power cable and control power cable. If those cables must intersect each other, then route them so that they intersect at right angles as shown below. The robot driver may result in malfunction if the cables are not separated from each other.


Main circuit power cable
(L1, L2, L3, U, V, W, (+), (+)1, RB)
Control power supply cable
(L1C, L2C)
Cables should intersect at right angles.
Signal input and position sensor cables
30cm or more

(4)Peripheral cables and products

	Name	Function	Availability
1	**TOP (software for YAMAHA RD series)**	Allows setting parameters, monitoring operation and displaying graphics from a PC connected to the robot driver.	Option
2	**Position sensor cable**	Connects to the robot position sensor, brake and origin sensor.	Standard
3	**Power cable**	Supplies power to the robot.	Standard
4	**PC connection cable**	Connects to a PC.	Option
5	**Connector set for I/O signals**	Mating connector and cover for robot driver I/O connector	Standard
6	**External braking resistor**	Boosts the braking capacity.	Option

Typical wiring diagram for robot driver is shown below.



(5)Recommended wire size and wiring accessories

- Select optimal breakers by taking their breaking capacity into account.
- Use an earth leakage breaker (ELB) to ensure safety.
- Use an appropriate copper wire with a heat resistant temperature of 75˚C or more.
- Tighten the terminal screws to the specified torque. Insufficient tightening may result in a short circuit or fire.
- Select the sensitivity current of the earth leakage breaker (ELB) by taking account of the total wiring length needed to connect between the robot driver and power supply and also between the robot driver and robot. When the total wiring length is shorter than 30 meters, use a 15mA sensitivity current (per one robot driver).
  Use an earth leakage breaker compatible with inverters. Conventional breakers may malfunction by high harmonics generated from an inverter. Contact the breaker manufacturer for details.

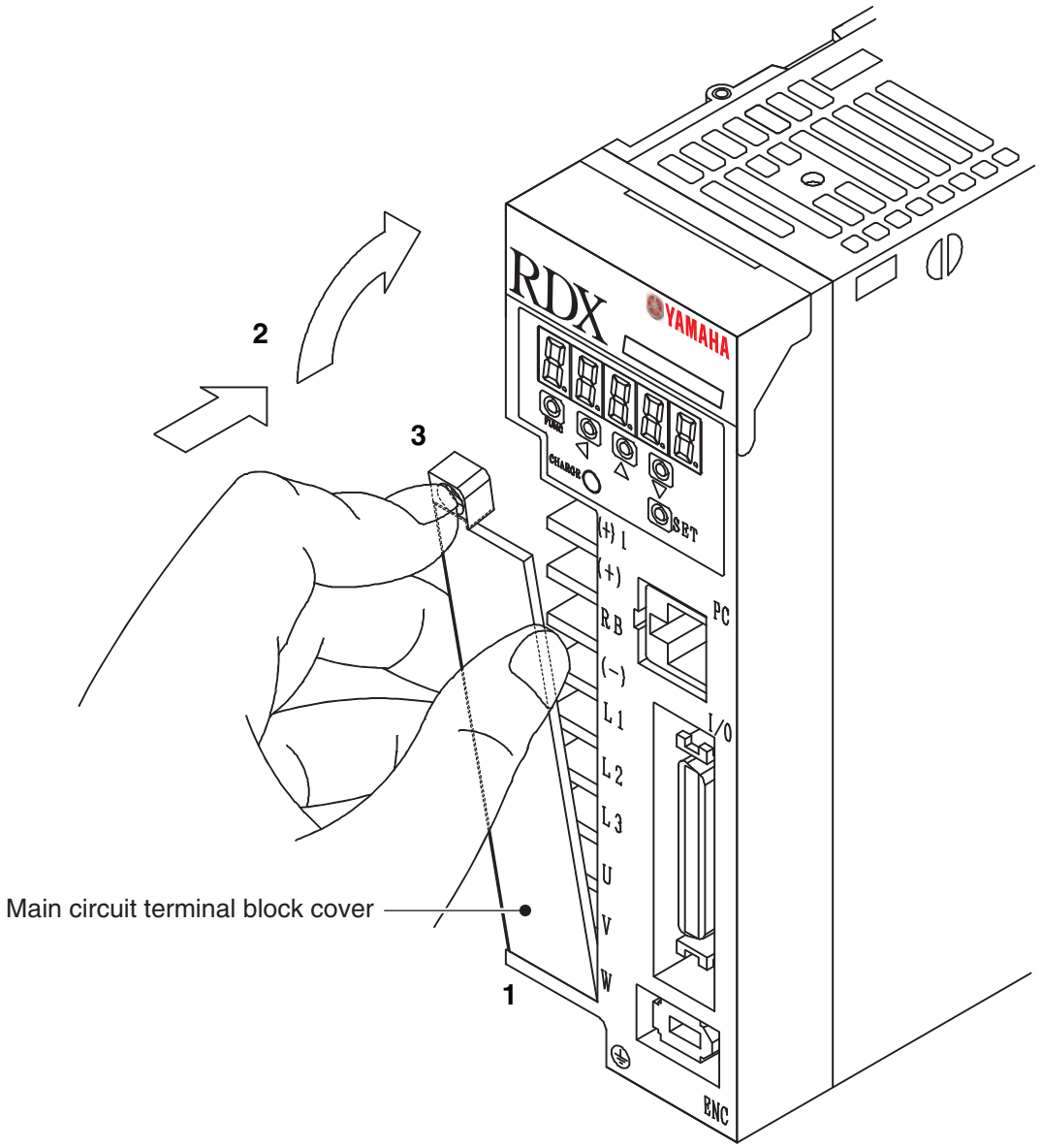
- Refer to the following table when selecting wiring size and wiring accessories for robot drivers.

Robot driver model	Main circuit power cable L1, L2, L3 (+)1, (+), RB, (–)	Control power cable L1C, L2C	Earth leakage breaker (ELB) *	Electromagnetic contactor (MC) *
RD*-05	1.25mm^2 or more	0.5mm^2 or more	EX30 (5A)	H10C / HK10
RD*-10	1.25mm^2 or more	0.5mm^2 or more	EX30 (5A)	H10C / HK10
RD*-20	1.25mm^2 or more	0.5mm^2 or more	EX30 (5A)	H10C / HK10
RDP-25	1.25mm^2 or more	0.5mm^2 or more	EX30 (10A)	H10C / HK10

* : ELB and MC models listed in the above table are manufactured by Hitachi Industrial Equipment Systems Co., Ltd.
(Hitachi standard ELB products manufactured from December 1987 are compatible with inverters.)

(6)Attaching the cover to the main circuit terminal block (TM1)

1. Insert the bottom hook of the main circuit terminal block cover into the slot in the robot driver front panel as shown below.
2. Attach the main circuit terminal block cover into place by gently pressing on it from the front.
3. Tighten the screw to fasten the main circuit terminal block cover to the robot driver.



3.2.3 Wiring to the control terminal block (TM2)

CAUTION

1. **Unplug the control power supply connector (TM2) from the robot driver before wiring.**
   Failure to do so may damage the robot driver.
2. **Insert one cable into one terminal hole of the control power connector (TM2).**
   Failure to follow this instruction may cause the robot driver to malfunction.
3. **When inserting the wires into the terminal, be careful not to bring the core wire braid into contact with other conductive parts.**
   Failure to do so may damage the robot driver.
4. **If for some reason the inserted portion of the wire is frayed, cut off that frayed portion and restrip the wire. Then reconnect the wire securely.**
   Using frayed wire might damage the robot driver.

(1) Cable termination

Strip the cable sheath as shown in Fig. 1. The cable can then be used as is. Applicable wire size is as follows:

Solid wire .....Wire size 1.25 to 2.0mm^2

Stranded wire...Wire size 1.25 to 2.0mm^2

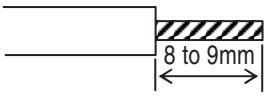


Fig. 1 Control power cable termination

(2) Connection method

Insert the core wire of the cable into the terminal hole of the control power connector (TM2) shown in Fig. 2 by using either of the following methods of Fig. 3 and Fig. 4. Make sure the wire does not come loose if pulled.

1) Insert the wire by using the supplied lever as shown in Fig. 3.
2) Insert the wire by using a small flat-blade screwdriver as shown in Fig. 4.

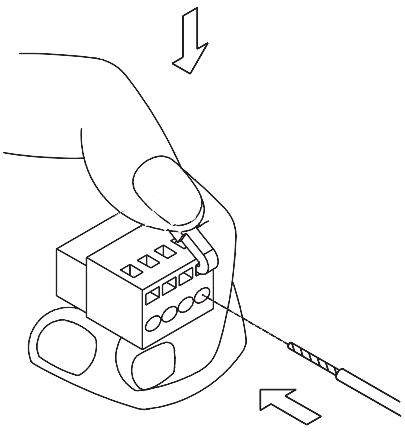


Fig. 3

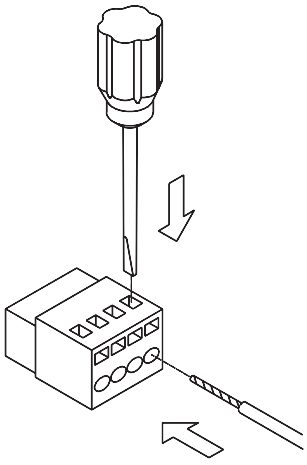


Fig. 4

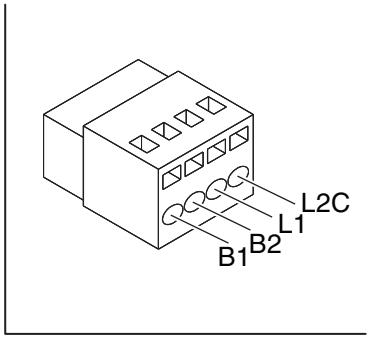
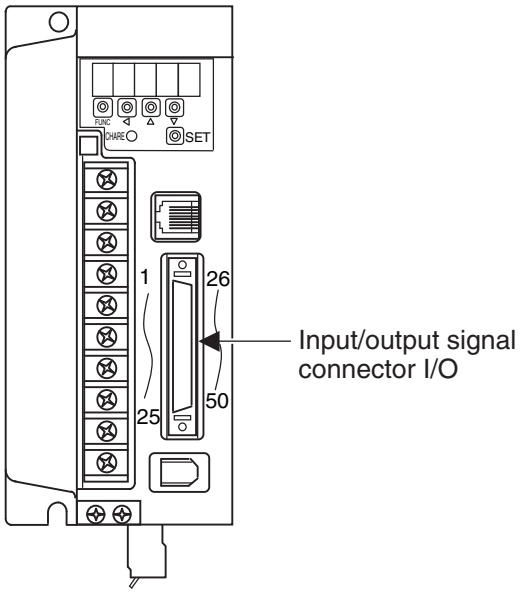


Fig. 2 Control power connector

3.2.4 Input/output signal wiring

(1)Input/output signal connector

Pin No.1 of the input/output signal connector I/O is located at the upper left when viewed from the front of the robot driver as shown on the right. The table below shows the signal assignment on the input/output signal connector I/O (robot driver side).



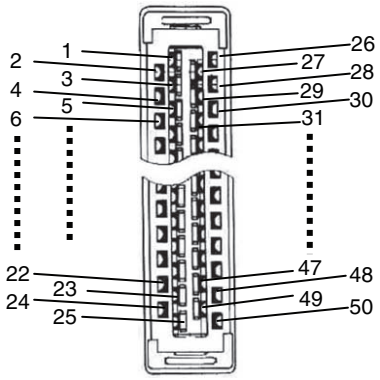
Robot driver front view

Pin No.	Pin symbol	Signal name	Pin No.	Pin symbol	Signal name
1	P24	Interface power	26	SON	Servo ON
2	PLC	Intelligent input common	27	RS	Alarm reset
3	–	–	28	FOT	Forward overtravel
4	TL	Torque limit	29	ROT	Reverse overtravel
5	B24	Brake power input (24V)	30	CM1	Interface power common
6	B0	Brake power input (0V)	31	B0	Brake power input (0V)
7	–	–	32	ORG	Return-to-origin (homing)
8	ORL	Origin sensor	33	PEN	Pulse train input enable
9	CER	Position error clear	34	ALME	Alarm (emitter)
10	CM1	Interface power common	35	SRD	Servo ready (collector)
11	ALM	Alarm (collector)	36	–	–
12	INP	Positioning complete (collector)	37	–	–
13	BK	Brake release relay output	38	–	–
14	–	–	39	INPE	Positioning complete (emitter)
15	PLSP	Position command pulse (P)	40	SIGP	Position command sign (P)
16	PLSN	Position command pulse (N)	41	SIGN	Position command sign (N)
17	–	–	42	SRDE	Servo ready (emitter)
18	–	–	43	–	–
19	–	–	44	–	–
20	L	Analog input /output common	45	–	–
21	OAP	Phase A signal output (P)	46	OBP	Phase B signal output (P)
22	OAN	Phase A signal output (N)	47	OBN	Phase B signal output (N)
23	OZP	Phase Z signal output (P)	48	OZ	Phase Z detection
24	OZN	Phase Z signal output (N)	49	L	Phase Z detection common
25	AO1	Analog monitor 1	50	AO2	Analog monitor 2

On the mating input/output signal connector (cable side), pin No.1 is located at the upper left when viewed from the soldered side (inner side) as shown below.

The following connector is supplied with the controller as the input/output signal connector (cable side).

Product name	Type No.	Manufacturer
Connector plug	10150-3000PE (soldered)	Sumitomo 3M
Connector cover non-shield shell kit	10350-52A0-008	Sumitomo 3M



Soldered side of input/output signal connector

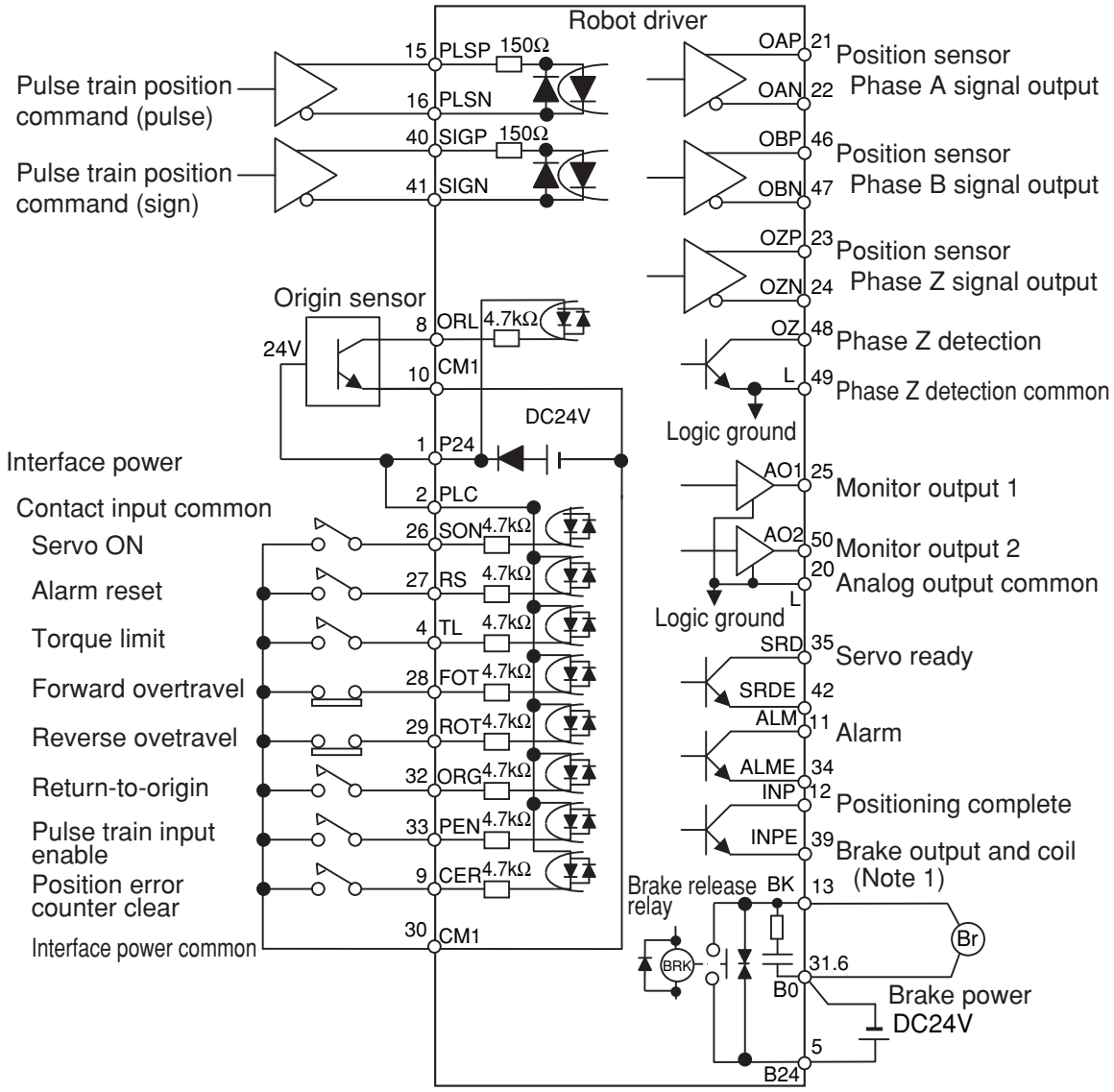
2	PLC	1	P24	27	RS	26	SON
4	TL	3	–	29	ROT	28	FOT
6	BO	5	B24	31	BO	30	CM1
8	ORL	7	–	33	PEN	32	ORG
10	CM1	9	CER	35	SRD	34	ALME
12	INP	11	ALM	37	–	36	–
14	–	13	BK	39	INPE	38	–
16	PLSN	15	PLSP	41	SIGN	40	SIGP
18	–	17	–	43	–	42	SRDE
20	L	19	–	45	–	44	–
22	OAN	21	OAP	47	OBN	46	OBP
24	OZN	23	OZP	49	L	48	OZ
		25	AO1			50	AO2

Note 1: For robots using an origin sensor or robots equipped with a mechanical brake, the input/output signal connector is shipped with pin No. 1, 8, 10, 13 and 31 soldered.

Note 2: Brake release relay output (BK) is not available from the RDP.

(2)Input/output signal connection diagram

Standard input/output signal connections are shown below.



The above diagram shows a sink type output module using a power supply for internal input.

(3)Input/output signal functions

Input/output signal functions are summarized in the following table.

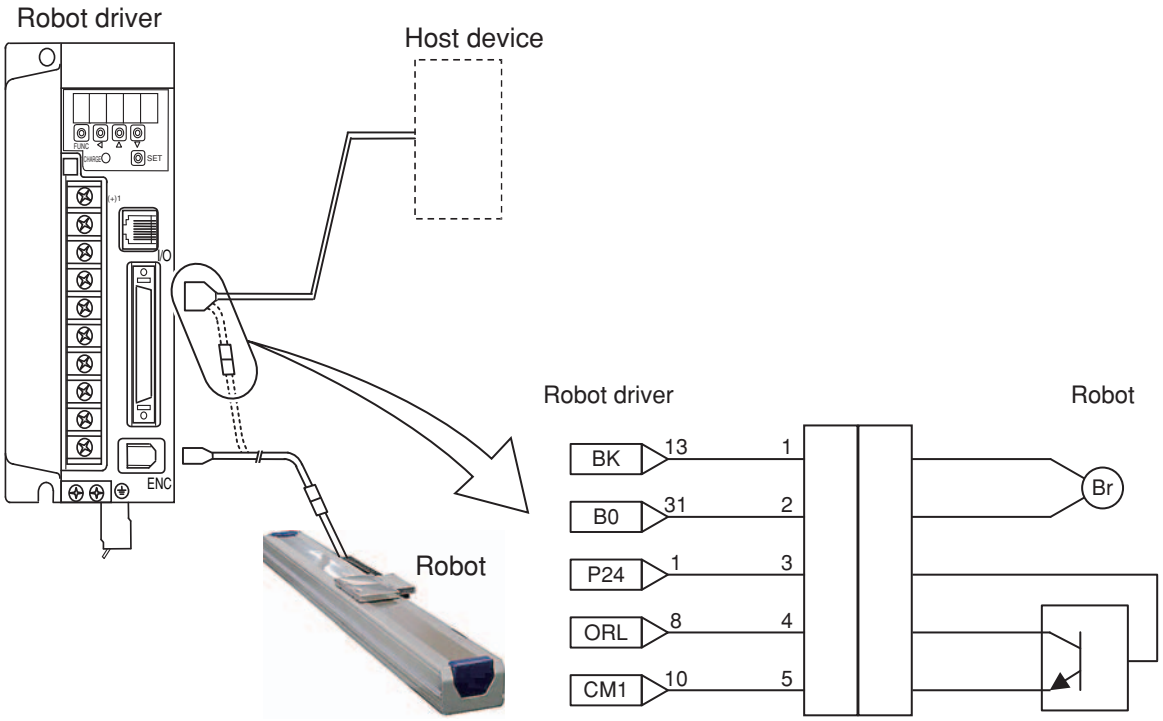
Type	Terminal symbol	Terminal name	Description	Electrical specifications
Input signal	P24	Interface power	Supplies 24V DC for contact inputs. Connecting this signal to the PLC terminal allows using the internal power supply. Use this terminal only for contact input. Do not use for controlling external equipment connected to the robot driver, such as brakes.	DC +24V±10% 80mA max.
	CM1	Interface power common	This is a ground signal for the power supply connected to P24. If using the internal power supply then input a contact signal between this signal and the contact-point signal.	
	PLC	Intelligent input common	Connect this signal to the power supply common contact input. Connect an external supply or internal power supply (P24).	
	SON	Servo ON	Setting this signal to ON turns the servo on (supplies power to motor to control it). This signal is also used for estimating magnetic pole position when FA-90 is set to oFF2.	Contact input Close: ON Open: OFF 5mA (at 24V) per input
	RS	Alarm reset	After an alarm has tripped, inputting this signal cancels the alarm. But before inputting this reset signal, first set the SON terminal to OFF and eliminate the cause of the trouble.	
	TL	Torque limit	When this signal is ON, the torque limit is enabled.	
	FOT	Forward overtravel	When this signal is OFF, the robot will not run in forward direction. (Forward direction limit signal)	
	ROT	Reverse overtravel	When this signal is OFF, the robot will not run in reverse direction. (Reverse direction limit signal)	
	ORL	Origin sensor	Input an origin limit switch signal showing the origin area.	
	ORG	Return-to-origin	Inputting this signal starts return-to-origin operation.	
	PEN	Pulse train input enable	When this signal is turned on, the pulse train position command input is enabled.	
	CER	Position error counter clear	Inputting this signal clears the position deviation (position error) counter. (Position command value is viewed as current position.)	
Analog common	L	Analog common	This is the ground for the analog signal.	0 to ±10V Input impedance: approx. 10kΩ

Type	Terminal symbol	Terminal name	Description	Electrical specifications
Output signal	SRD SRDE	Servo ready	This signal is output when the servo is ready to turn on (with main power supply turned on and no alarms tripped.)	Open collector and emitter signal output +30V DC or less, 50mA max. per output
	ALM ALME	Alarm	An alarm signal is output when an alarm has tripped. (This signal is ON in normal state and OFF when an alarm has tripped.)	
	INP INPE	Positioning complete	This signal is output when the deviation between the command position and current position is within the preset positioning range.	
Relay output	BK (B24) (Note 1)	Brake release relay output	When the servo is ON, this terminal outputs a signal to allow releasing the brake. (FLIP-X series only)	24V DC 375mA max.
Monitor output	AO1	Monitor output 1	Outputs speed detection values, torque commands, etc. as analog signal voltages for monitoring. Signals to output are selected by setting parameters. These signals are only for monitoring. Do not use for control.	0 to ±3.0V Load impedance: 3kΩ or more
	AO2	Monitor output 2		
	L	Monitor output common	This is the ground for the monitor signal.	
Position command	PLSP	Position command pulse (pulse signal)	Select one of the following signal forms as the pulse-train position command input. (1) Command pulse + direction signal (2) Forward direction pulse train + reverse direction pulse train (3) Phase difference 2-phase pulse	Line driver input
	PLSN			
	SIGP	Position command pulse (sign signal)		
	SIGN			
Position sensor monitor	OAP	Position sensor Phase A signal	Outputs monitor signal obtained by dividing "phase A" signal of position sensor.	Line driver signal output
	OAN			
	OBP	Position sensor Phase B signal	Outputs monitor signal obtained by dividing "phase B" signal of position sensor.	
	OBN			
	OZP	Position sensor Phase Z signal	Outputs monitor signal for position sensor "phase Z" signal.	
	OZN			
	OZ	Phase Z detection	Outputs monitor signal for position sensor "phase Z" signal.	Open collector output +30V DC or less, 50mA max.
	L	Phase Z detection common		
Brake power input	B24 (Note 1)	Brake power input	Input 24V DC brake power to this terminal	24V DC input
	B0 (Note 1)	Brake power common	Common terminal input for brake power	

Note 1:B24, BO and BK are available only with RDX, and not with RDP.

(4)Brake and origin sensor connector

Among the input/output signals, the brake and origin sensor signals are connected to a connector that is branched from the input/output signal connector. By connecting this branched connector to the position sensor cable, the brake can be released and return-to-origin performed by sensor method.
Use this connector only when using a robot with a mechanical brake or robot's return-to-origin method is sensor method.

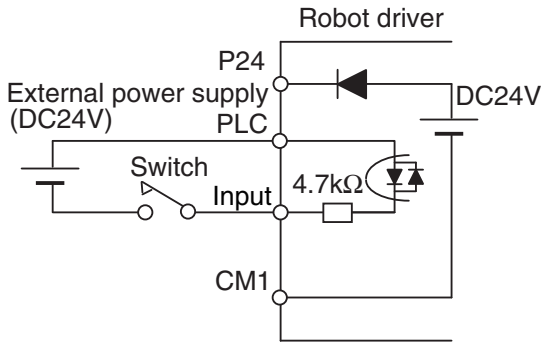


Pin No. on connector side	Terminal symbol	Signal name	Pin No. on robot driver side
1	BK	Brake release relay output	13
2	B0	Brake power input (0V)	31
3	P24	Power supply for input signal	1
4	ORL	Origin sensor	8
5	CM1	Power supply (common) for input signal	10

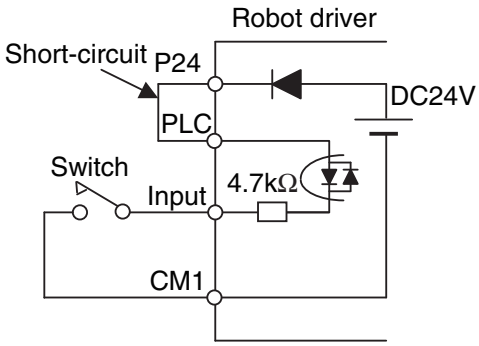
(5)Details of input/output signal wiring

1) Contact input signal

- Contact signals should be input through switches and relays. Figures (a) and (b) below show wiring diagrams using an external power supply or internal interface power supply.

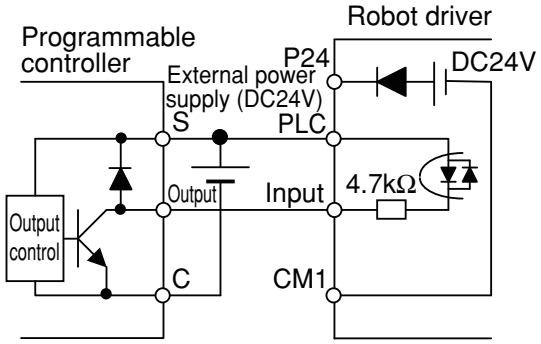


(a) When using an external power supply

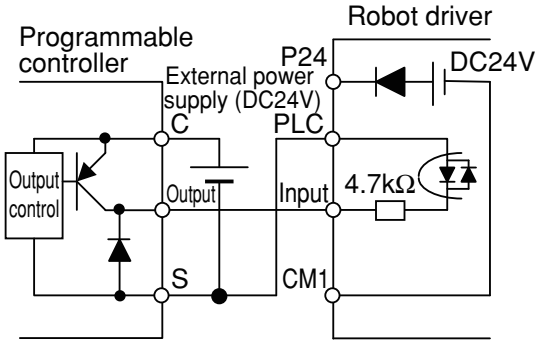


(b) When using the internal power supply

- Use an external power supply for devices requiring power for controlling a contact output, such as a programmable controller output module. (Do not use the internal interface power supply of the robot driver.) Figures (c) and (d) below show examples for connecting the transistor output module (sink type or source type) of a programmable controller.

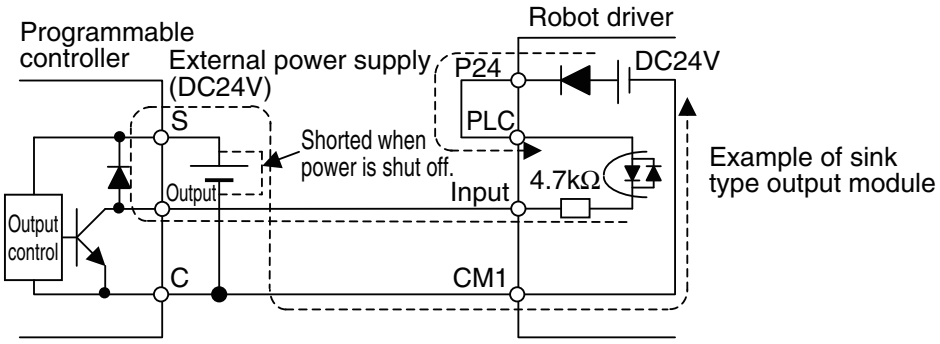


(c) When using a sink type output module and an external power supply



(d) When using a source type output module and an external power supply

• When using an external power supply, do not connect to the internal interface power of the robot driver. If connected, current may flow as shown in figure (e) below when the external power supply is shut off, causing the input to turn on.



(e) Current flow when external power supply is shut off

• If using switch contacts or relay contacts as the contact input signal, then use contacts such as crossbar twin contacts that make good contact even at weak currents or voltages.

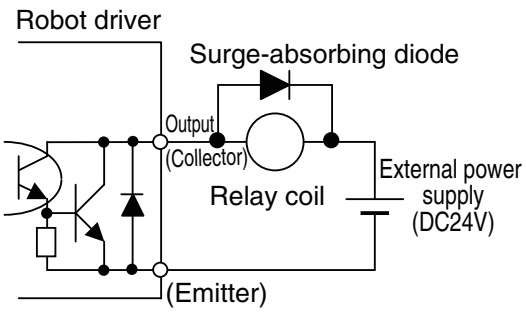
• Do not short the internal interface power P24 to CM1. The robot driver may fail.

• The electrical specifications for input signals are shown in the following table. (Power supply voltage 24V DC)

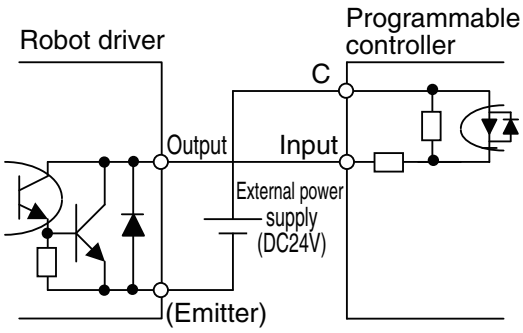
Item	Unit	Minimum	Maximum	Condition
Input impedance	kΩ	4.5	5.7	
Input current at OFF	mA	0	0.3	
Input current at ON	mA	3.0	5.2	Power supply voltage 24V DC

2) Open collector output signal

- Connect a relay coil or the input module of a programmable controller as shown in Figures (a) and (b) below. When using a relay, connect a diode as a surge absorber in parallel with the coil. Connect that diode as shown in Figure (a) so that the current flow direction of the diode is opposite the direction that voltage is applied to the coil.



(a) Relay coil connection



(b) Programmable controller connection

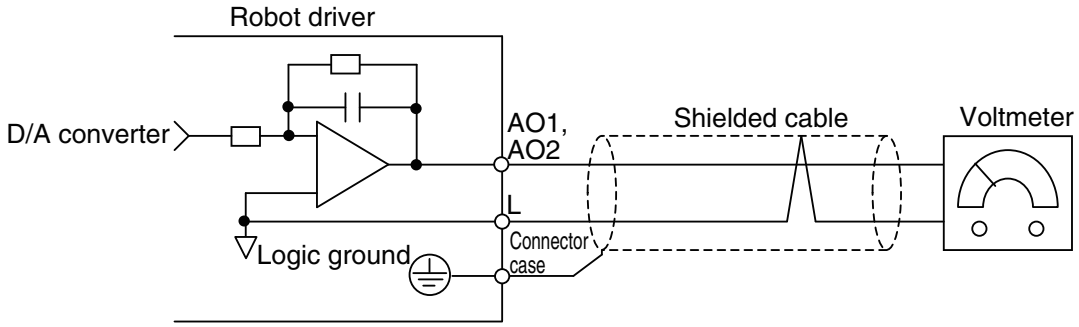
- Prepare an external power supply for output signals. Do not use the internal interface power supply (P24-CM1) of the robot driver. The robot driver may fail.

- Electrical specifications for contact output signals are shown in the following table.

Item	Unit	Minimum	Maximum	Condition
Output power supply voltage	V	–	30	
Output current at ON	mA	–	50	
Leakage current at output OFF	mA	–	0.1	
Output saturation voltage at ON	V	0.5	1.5	Output current 50mA

3) Monitor output signal

- Connect a meter (voltmeter) or recorder for monitoring speed detection values and torque command values as shown in Figure (a) below. Use this signal only for monitoring and not for commands to other control devices. (Output signal accuracy is about ±10%.) Each monitor output signal cable should be a shielded, twisted pair cable with the analog common (L--- connector pin No. 20, 49). Connect the cable shield to ground (⏚) on the robot driver side. (The I/O connector case of the robot driver is internally connected to the ground.)



(a) Monitor output signal connection

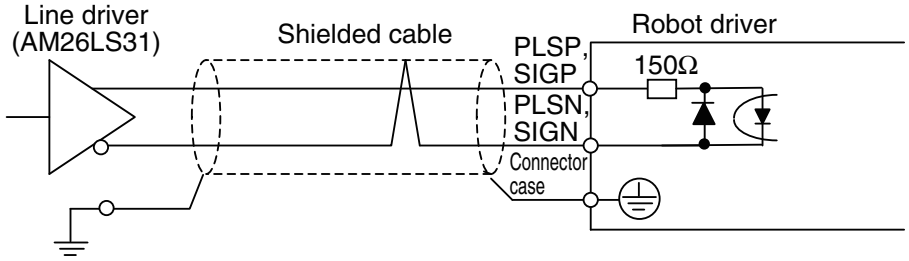
- The impedance of the load to connect to this monitor signal should be 3kΩ or more.
  Do not connect the monitor output signal (AO1, AO2) to the common (L) or another power supply. The robot driver may fail.

- Electrical specifications for monitor output signals are shown in the following table.

Item	Unit	Specifications
Output voltage	V	0 to ±3.0
Load impedance	kΩ	3.0 or more
Output voltage accuracy	%	±10 or more
Output signal delay time	ms	Approx. 1

4) Position command signal

- Connect the pulse train signal for position command. As shown in the figure below, the line receiver receives a pulse train signal output from the line driver (AM26LS31 or equivalent) of the master controller.
  Each position command signal cable should be a shielded, twisted pair cable. Connect the cable shield to ground (⏚) on the robot driver side. (The I/O connector case of the robot driver is internally connected to the ground.)

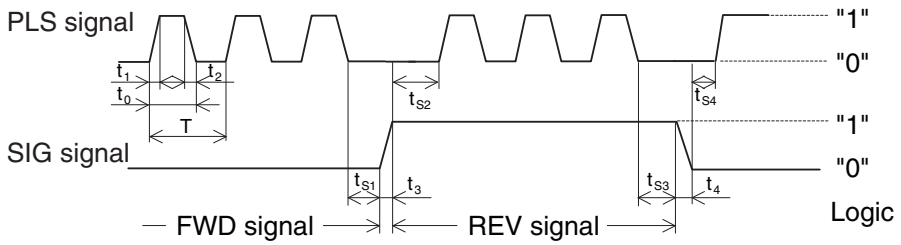
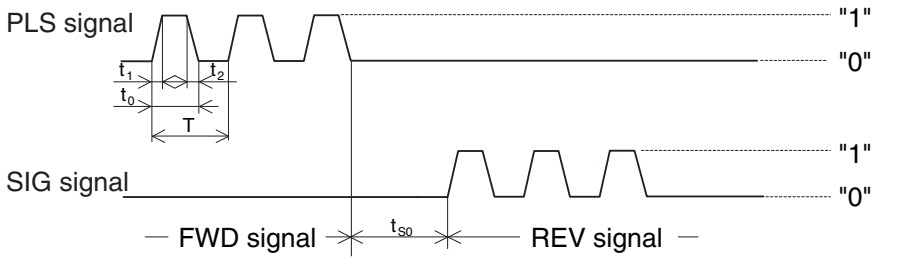
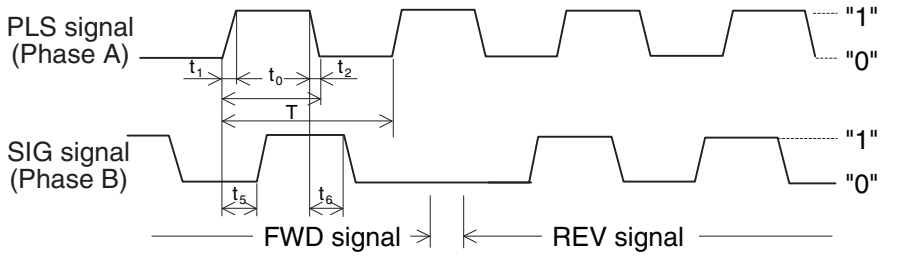


- Electrical specifications and timing chart for position pulse signals are shown in the following table.

Electrical specifications for position command pulses

Item		Unit	Specifications	Condition
Input current of logic 1		mA	8 to 15	
Maximum input pulse rate (Frequency)	• **FWD/REV pulse input** • **Command pulse + sign input**	pulses/s	2M	Line driver signal
	• **Phase difference 90° pulse input**	pulses/s	500k	Line driver signal

Position command pulse timing chart

Pulse train signal form	Pulse train input timing
(1) Pulse train command	When FA-11 = P-S (Movement direction is reversed if FA-11 = -P-S.) See note below. 
(2) FWD/REV pulse	When FA-11 = F-r (Movement direction is reversed if FA-11 = r-F.) See note below. 
(3) Phase difference 2-phase pulse *** In the case of phase difference 2-phase pulse, the count is multiplied by 4.**	When FA-11 = A-b (Movement direction is reversed if FA-11 = b-A.) See note below. 

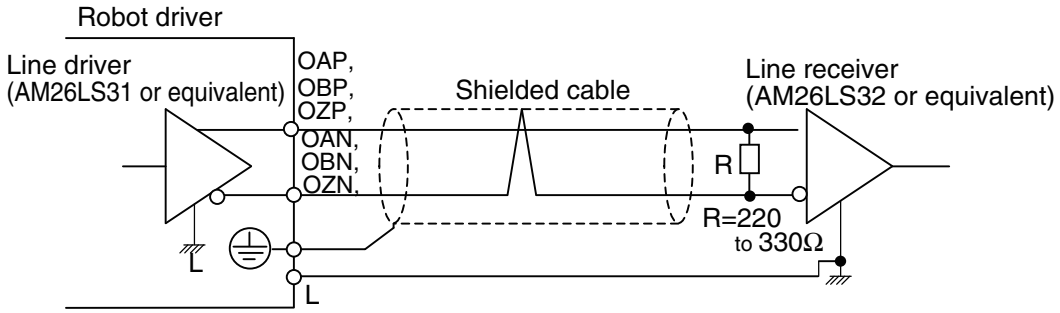
Note: When at logic 1, the pulse train input current direction is PLSP→PLSN, SIGP→SIGN.

Position command pulse timing values

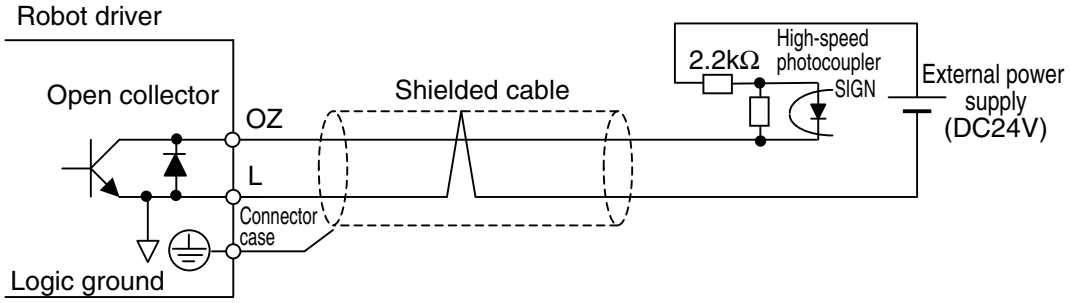
Pulse train signal form (See above)			Line driver signal	
			(1), (2) above	(3) above
Timing values	**Rise time**	: t_1, t_3	0.1µs or less	0.1µs or less
	Fall time	: t_2, t_4	0.1µs or less	0.1µs or less
	Switching time	: t_{S0}, t_{S1}, t_{S2}, t_{S3}, t_{S4}	3µs or more	–
	Phase difference	: t_5, t_6	–	
	Pulse width	: $(t_0/T)\times100$	50±10%	50±10%
Maximum pulse rate (frequency)			2M (pulses/s)	500k (pulses/s)

5) Position sensor monitor signal

- The position sensor signal is output as phase A, B, and Z signals. The line driver output signals (OAP-OAN, OBP-OBN, OZP-OZN) should be connected to the line receiver (input impedance: 220 to 330 Ω) as shown in Figure (a) below. The open collector output signal (OZ-L) should be connected to the input device as shown in Figure (b). Use a shielded, twisted pair cable for each position sensor monitor signal cable. Connect the cable shield to ground (⏚) on the robot driver side. (The I/O connector case of the robot driver is internally connected to the ground.)



(a) Line driver output signal connection



(b) Open collector output signal connection

- This signal is output as a high speed signal (1MHz for phase A and B signals) depending on the division ratio setting for the position sensor monitor signal. So use a noise-shielded cable and a receiving circuit designed to handle high-speed signals. When the open collector output of phase Z signal is received by a photocoupler, be sure to use a high-speed photocoupler (1MHz or more).
- The cable length for this signal should be 3 meters or less. Install this wiring as far apart as possible from the main circuit cable and the relay control cable.
- Do not short the line driver output signals to each other or connect them to another power supply. The robot driver may fail.
- Electrical specifications for the line driver signal output conform to those of general-purpose line drivers (AM26LS31 or equivalent). Electrical specifications for the phase Z detection signal of the open collector are shown in the following table.

Item	Unit	Minimum	Maximum	Condition
Output power supply voltage	V	4	30	
Output current at ON	mA	0	50	
Leakage current at output OFF	mA	0	0.1	
Output saturation voltage at ON	V	0	0.4	Output current 50mA

3.2.5 Wiring for position sensor signals

(1)Position sensor signal connector

Connector compatible with lead-free solder

Type No.	Manufacturer
54599-1015	Molex

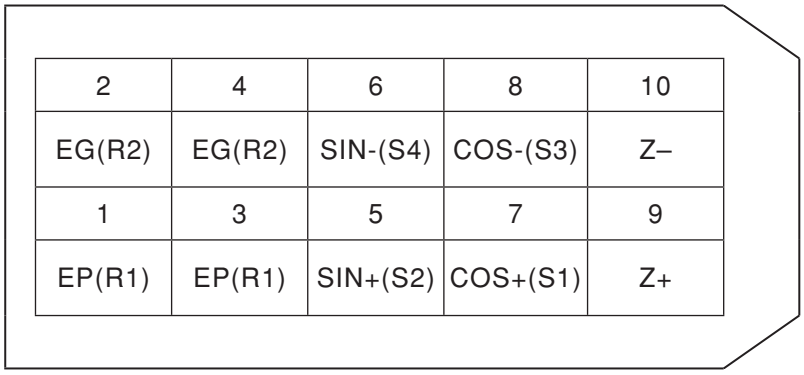
- **Description of terminal code**

RDP ENC connector terminal symbol

Pin No.	Terminal symbol	Signal name	Pin No.	Terminal symbol	Signal name
1	EP	Position sensor power supply 5V	2	EG	Position sensor power supply Common 0V
3	EP		4	EG	
5	SIN+	Sine output (+)	6	SIN–	Sine output (–)
7	COS+	Cosine output (+)	8	COS–	Cosine output (–)
9	Z+	Phase Z (+) output	10	Z–	Phase Z (–) output

RDX ENC connector terminal symbol

Pin No.	Terminal symbol	Signal name	Pin No.	Terminal symbol	Signal name
1	R1	Position sensor excitation input terminal	2	R2	Position sensor excitation input terminal
3	R1		4	R2	
5	S2	S2-S4 coil output terminal	6	S4	S2-S4 coil output terminal
7	S1	S1-S3 coil output terminal	8	S3	S1-S3 coil output terminal
9	–	–	10	–	–



Numbers in parentheses indicate position sensors used with the RDX.

MEMO

Chapter 4 Operation

This chapter explains typical product operation and shows simple trial runs.

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4.1 Control and operation 4-1

4.1.1 Position control by pulse train input 4-2

4.2 Test Run 4-3

4.2.1 Jog from the digital operator 4-3

4.2.2 Making a test run using "TOP" software for RD series 4-4

4.3 Emergency stop 4-6

4.1 Control and operation

CAUTION

1. To prevent unstable or erratic operation never make drastic adjustments to the unit. Doing so may cause injury.
2. Install a safety circuit that actuates an electromagnetic contactor to cut off the main circuit power supply in case of an alarm.
3. If an alarm has occurred, eliminate the cause of the alarm and ensure safety. Then reset the alarm and restart the operation.
   Failure to do so may cause injury.
4. If a momentary power outage occurs and power is restored, the unit might suddenly restart so do not approach the machine at that time. (Design the machine so that personal safety is ensured even if it suddenly restarts.)
   Failure to do so may cause injury.
5. Make sure that the AC power specifications match the product power specifications.
   Using the wrong power specifications may cause injury.
6. While power is being supplied, do not touch any parts inside the robot driver or its terminals.
   Also, do not check the signals or attach/detach the cables.
   Doing so may cause electrical shock or injury.
7. While power is being supplied, do not touch any terminals on the robot driver even if the robot is stopped.
   Doing so may cause electrical shock or fire.
8. This product does not incorporate any power failure detection function. When necessary, install an external power failure detection circuit and configure an appropriate circuit that stops the operation safely when a power failure is detected. (Refer to 4.3, "Emergency stop", in this chapter.)

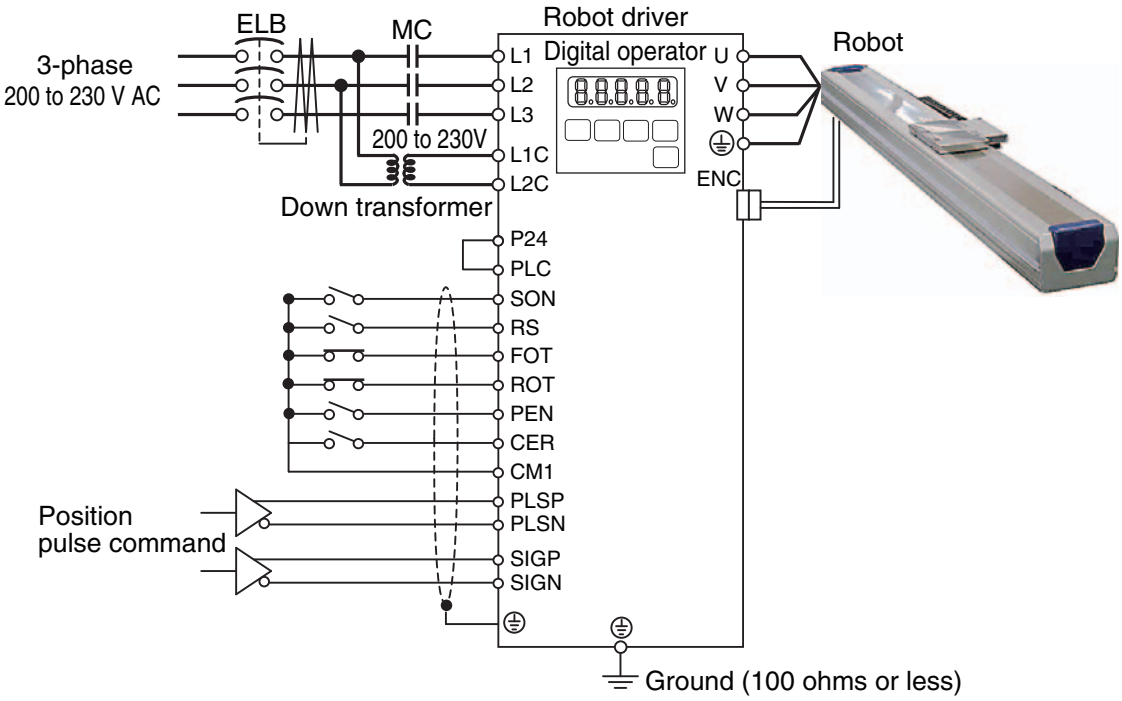
MANDATORY

INSTALL AN EXTERNAL EMERGENCY STOP CIRCUIT SO THAT YOU CAN IMMEDIATELY STOP OPERATION AND SHUT OFF POWER WHENEVER NEEDED.

4.1.1 Position control by pulse train input

This method controls the position with external pulse train signals.

1) Make connections as shown below and check that they are correct.
2) Turn on the ELB (earth leakage breaker) and then turn on the control power to the robot driver.
   The digital operator comes on and "d-00" is displayed. (This is the factory default setting.)
3) Set the "Pulse train input mode" (FA-11) parameter.
4) Set the "Electronic gear numerator/denominator" (FA-12, FA-13) parameters.
   (These are set by default so that 1 pulse is equal to a 1µm position command.)
5) Check that the "Control mode" (FA-00) parameter is set to "Position control" (P-S).
6) Turn on the FOT and ROT terminals.
7) Turn on the electromagnetic contactor MC and then turn on the main circuit power supply.
8) Turn on the SON terminal. (On the RDP, magnetic pole position is found right after power is first turned on.)
9) Turn on the PEN terminal and input the position pulse command. (The robot will move to the commanded position.)
   To stop the robot, turn off the PEN terminal after completing positioning. Check that the robot has stopped and then turn off the SON terminal.



The above diagram shows a sink type output module using a power supply for internal input.

4.2 Test Run

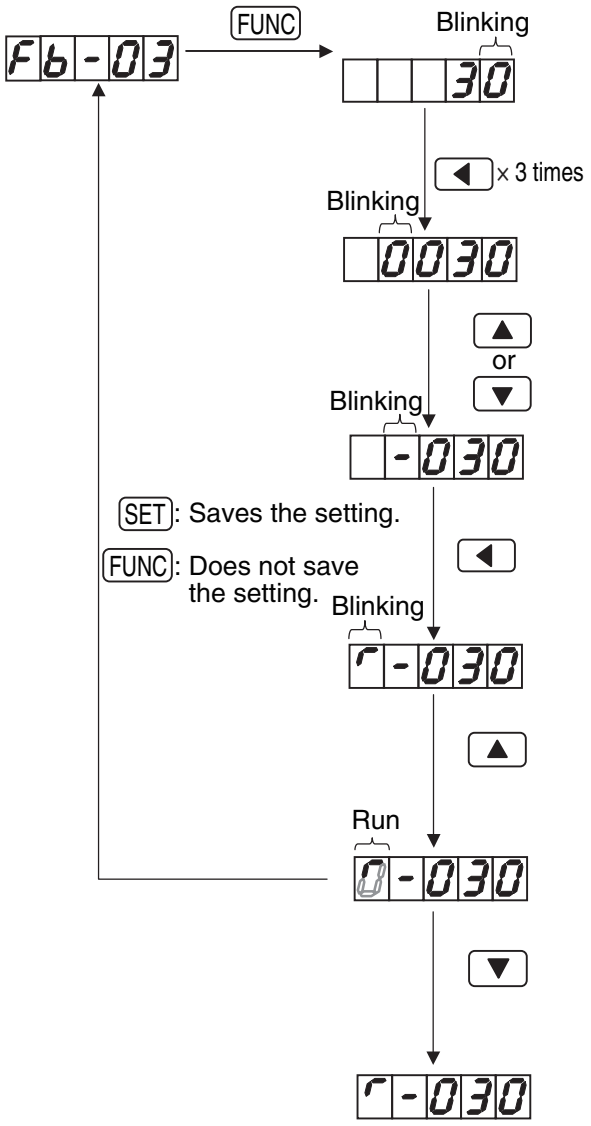
This section explains how to make a test run.

4.2.1 Jog from the digital operator

Jog can be performed from the digital operator just by wiring the robot driver to the robot and power supply.
This test run method allows checking the wiring between the robot driver, robot and power supply.

(1)Jog operation

Perform the following steps with the SON terminal turned off.



1) Operate the FUNC and ▼ keys to show the "Jogging speed" (Fb-03) parameter setting.

2) Set the operation speed by using the ◄ , ▼ and ▲ keys. (The example on the left shows the operating procedure for changing only the run direction.)
To reverse the run direction, set the speed with a negative sign. Enter the sign in the second digit column from the left on the LED display.

3) To perform jog operation, select the most significant digit with the ◄ key.

4) Press the ▲ key while in the above state.
Jog operation now starts to move the robot, so use caution.

5) Press any of the following keys to stop the operation.
▼ key: Continues displaying the setting.
SET key: Saves the speed setting.
FUNC key: Returns to the menu display without saving the speed setting.

Note: When a PHASER series robot is used, magnetic pole position estimation must be performed before this operation. For information on magnetic pole position estimation,refer to section 5.17, "Magnetic pole position estimation action".

4.2.2 Making a test run using "TOP" software for RD series

Jog can be run from a PC. During this jog operation, wiring checks can be made for the robot driver, robot and power supply because no outside connections to the I/O connector are needed. For details, refer to the TOP (software for RD series) user's manual.

There are two types of jog operation: (1) normal jog performed at a specified speed and (2) pulse feed jog that moves a distance equal to a specified number of pulses.
Each of these is explained below.

Note 1: Do not input any signals through the I/O connector including the SON terminal during this operation. Doing so runs the operation according to the input terminal.

Note 2: In this jog operation, the robot moves at an acceleration/deceleration time of 0 seconds and the current settings for control gain and speed limit parameters.

Note 3: This jog operation cannot be used simultaneously with the TOP monitor display.

Note 4: When a PHASER series robot is used, magnetic pole position estimation must be performed before this operation. For information on magnetic pole position estimation,refer to section 5.17, "Magnetic pole position estimation action".

(1)Operation in normal jog

In normal jog, the robot moves at a constant speed specified by the speed command until a stop command is input.
After starting the TOP (software for RD series), run the jog operation as explained below.

1) After connecting the TOP to the robot driver, click the (Test Run and Adjustment) button on the opening screen.
   (Click the (Jogging) tab.)
2) Enter the speed command for jog operation.
3) Check safety and then click the button that indicates the direction to move the robot.
   (The robot will start moving in the specified direction.)
4) Click the (Stop) button to stop operation.

Note: The robot moves during this operation, so check safety before starting operation.

(2)Pulse feed jog operation

In this jog operation, the robot moves in position control mode up to the position specified by the position command.
After starting the TOP software for RD series, run jog operation as explained below.
Refer to the TOP software user's manual for details.

1) Click the (Test Run and Adjustment) button on the opening screen.
   (Click the (Jogging) tab.)
2) Enter the number of feed pulses.
3) Check safety and then click the (Forward) or (Reverse) button.
   (The robot will start moving in the specified direction and stop at the position specified by the command.)
4) After positioning is complete, the display returns to the initial screen.
   The servo is still ON at this point so click the (Stop) button.

Note: The robot moves during this operation, so check safety before starting operation.
To stop positioning, click [Stop] button.

4.3 Emergency stop

To safely stop the robot in case of an emergency, configure an emergency stop circuit while referring to the explanations below.
For details on input terminal functions and parameters, refer to 5.2, "Input terminal functions" and 6.3.2, "Setup parameter description".

(1)Servo OFF

When the SON signal is turned off, the servo is OFF and the braking is applied by the dynamic brake.

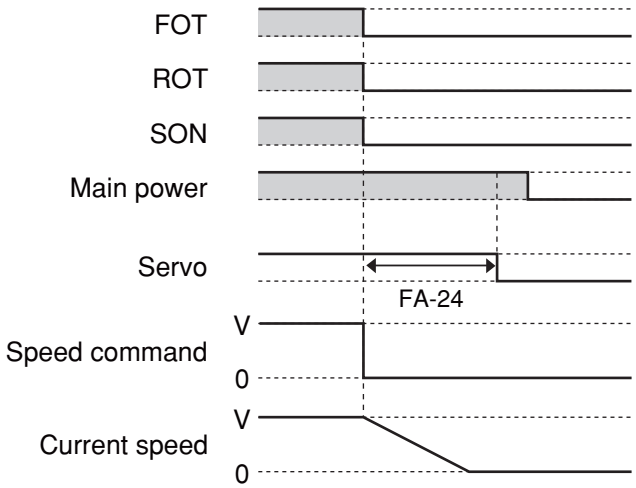
- The DB Operation selection (FA-16) must be set to "SoF". The braking is not applied by the dynamic brake unless this selection is set to "SoF".
- When the Servo OFF wait time (FA-24) is set, the servo is OFF and the braking is applied by the dynamic brake after the SON signal has been turned off and the servo OFF wait time has elapsed.

(2)How to shorten the braking distance

Shorten the breaking distance by producing the deceleration torque through the servo control.

Example) Deceleration torque is produced by clamping the speed command at zero.

- The servo OFF wait time is set, and the SON signal and FOT/ROT signal are turned off at the same time in case of an emergency.
- The speed command is clamped at zero by the FOT/ROT signal OFF while the servo OFF is delayed. At this time, the deceleration torque is produced to shorten the braking distance.



Note 1:If the heavy braking is applied as described in the example shown above when the payload of the robot is large or offset, the deceleration torque becomes too large, causing the robot to break. In this case, it is recommended that the FOT/ROT signal is not turned off and the position command is changed so that the speed command changes gradually.

Note 2:When the servo is OFF if a trip occurs, the power to the motor is shut down immediately even when the Servo OFF wait time has been set.

Chapter 5 Functions

This chapter explains the input/output signal functions of this product and its major control functions.

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5.1 Terminal function list

Type	Terminal symbol	Terminal name	Function
Contact point input signal	P24	Interface power	Supplies 24V DC for contact inputs. Connecting this signal to the PLC terminal allows using the internal power supply. Use this terminal only for contact input. Do not use for controlling external equipment connected to the robot driver, such as brakes.
	CM1	Interface power common	This is a ground signal for the power supply connected to P24. If using the internal power supply then input a contact signal between this signal and the contact-point signal.
	PLC	Intelligent input common	Connect this signal to the power supply common contact input. Connect an external supply or internal power supply (P24).
	SON	Servo ON	Setting this signal to ON turns the servo on (supplies power to motor to control it). This signal is also used for estimating magnetic pole position when FA-90 is set to oFF2.
	RS	Alarm reset	After an alarm has tripped, inputting this signal cancels the alarm. But before inputting this reset signal, first set the SON terminal to OFF and eliminate the cause of the trouble.
	TL	Torque limit	When this signal is ON, the torque limit is enabled.
	FOT	Forward overtravel	When this signal is OFF, the robot will not run in forward direction. (Forward direction limit signal)
	ROT	Reverse overtravel	When this signal is OFF, the robot will not run in reverse direction. (Reverse direction limit signal)
	ORL	Origin sensor	Input an origin limit switch signal showing the origin area.
	ORG	Return-to-origin	Inputting this signal starts return-to-origin operation.
	PEN	Pulse train input enable	When this signal is turned on, the pulse train position command input is enabled.
	CER	Position error counter clear	Inputting this signal clears the position deviation (position error) counter. (Position command value is viewed as current position.)
Analog common	L	Analog common	This is the ground for the analog signal.
Contact point output signal	SRD SRDE	Servo ready	This signal is output when the servo is ready to turn on (with main power supply turned on and no alarms tripped.)
	ALM ALME	Alarm	An alarm signal is output when an alarm has tripped. (This signal is ON in normal state and OFF if an alarm has tripped.)
	INP INPE	Positioning complete	This signal is output when the deviation between the command position and current position is within the preset positioning range.

Type	Terminal symbol	Terminal name	Function
Relay output	BK (B24)	Brake release relay output	When the servo is ON, this terminal outputs a signal to allow releasing the brake. (FLIP-X series only)
Monitor output	AO1	Monitor output 1	Outputs speed detection values, torque commands, etc. as analog signal voltages for monitoring. Signals to output are selected by setting parameters. These signals are only for monitoring. Do not use for control.
	AO2	Monitor output 2	
	L	Monitor output common	This is the ground for the monitor signal.
Position command	PLSP	Position command pulse (pulse signal)	Select one of the following signal forms as the pulse-train position command input. (1) Command pulse + direction signal (2) Forward direction pulse train + reverse direction pulse train (3) Phase difference 2-phase pulse
	PLSN		
	SIGP	Position command pulse (sign signal)	
	SIGN		
Position sensor monitor	OAP	Position sensor "phase A" signal	Outputs monitor signal obtained by dividing "phase A" signal of position sensor.
	OAN		
	OBP	Position sensor "phase B" signal	Outputs monitor signal obtained by dividing "phase B" signal of position sensor.
	OBN		
	OZP	Position sensor "phase Z" signal	Outputs monitor signal for position sensor "phase Z" signal.
	OZN		
	OZ	"Phase Z" detection	Outputs monitor signal for position sensor "phase Z" signal.
	L	"Phase Z" detection common	
Brake power input	B24	Brake power input	Input 24V DC brake power to this terminal.
	B0	Brake power common	Common terminal input for brake power.

5.2 Input terminal functions

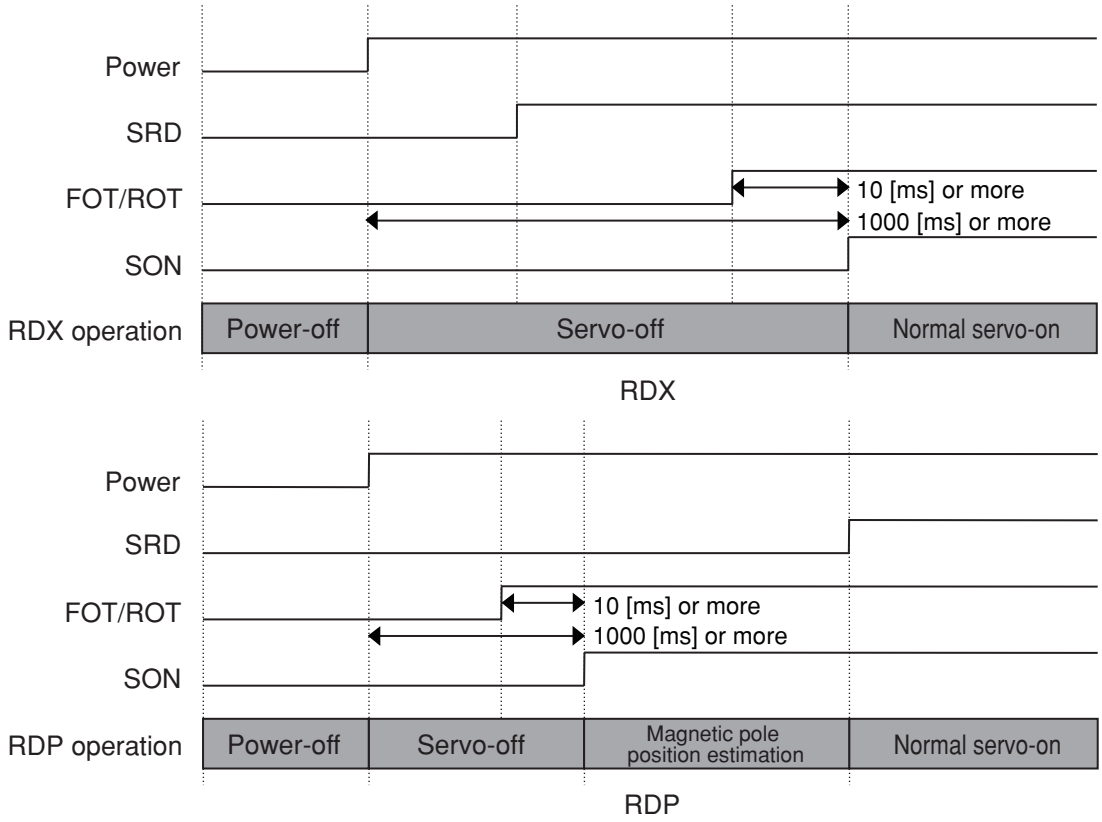
Functions of the robot driver input terminals are described below.
For details on input/output terminal timing chart from the power-on to the position command input, refer to 10.1, “Timing chart”, in Chapter 10.

SON terminal

Setting this signal to ON turns the servo on (supplies power to the servo).
The timing chart is shown below.
This signal is also used by the magnetic pole position estimation operation of the RDP. See 5.17, "Magnetic pole position estimation action" for more details.

Related parameters
FA-16 : DB Operation selection
FC-01 : Input terminal polarity setting

- Receives a servo-ON signal and enters the servo-ON state (when SRD is ON) only when the main circuit power supply is connected and no alarm has tripped. Unless all these conditions are met, no power is supplied even when this signal is ON. However, magnetic pole position estimation can be performed even if SRD is not ON.
- When the "DB operation selection" (FA-16) parameter is set to "SoF" (during servo OFF), the dynamic brake engages by turning the servo off.
- Period from input of a servo-ON signal until the operation is ready to start is 20ms.
- By changing the "Input terminal polarity" (FC-01) setting, the servo can also be turned on when this input terminal is opened.
- When the SON signal is switched from OFF to ON, the position command is set to the current position and the deviation (position error) counter is cleared.



RS terminal

When an alarm has tripped, setting the SON signal to OFF and this RS signal to ON clears the tripped alarm state, and operation can resume.

Related parameters

FC-01 : Input terminal polarity setting

- If no alarm has tripped, this signal is ignored even if set to ON.
- When an alarm has tripped and then this signal is switched from OFF to ON, the alarm trip state is canceled if the ON state lasts more than 20ms.
- Even if this signal remains at the ON state, reset operation is performed only once.
- By changing the "Input terminal polarity" (FC-01) setting, alarms can also be reset when this input terminal is opened.
- The RS terminal might not always be able to cancel a tripped state, due to the problem that triggered the alarm. See "9.3 Troubleshooting".

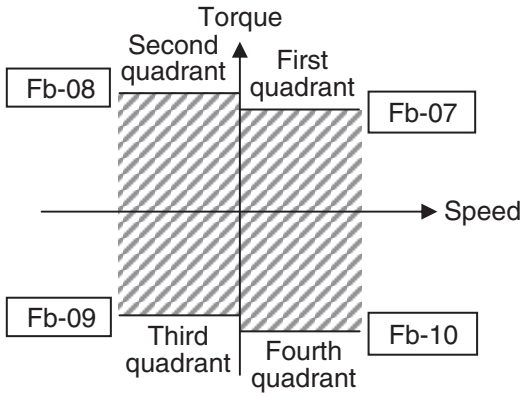
TL terminal

Setting this terminal to ON enables torque limit. Use the parameters Fb-07 through Fb-10 to determine the torque limit values.

Related parameters

FA-00 : Control mode
FA-17 : Torque limit mode
Fb-07 to 10 : Torque limit value 1 to 4
FC-01 : Input terminal polarity setting

- By changing the "Input terminal polarity" (FC-01) setting, torque limit can also be enabled when this input terminal is opened.
- The parameters Fb-07 through Fb-10 limit the torque in each quadrant as shown in the figure below. (However, use the absolute value as the torque limit value when entering the parameters.)



FOT/ROT terminals

These terminals connect to operating range limit switches in order to prevent overtravel.

Related parameters

FC-01 : Input terminal polarity setting

- When this signal is turned on, drive is allowed.
- To prevent overtravel, the internal speed command limit value in that direction is set to 0.
- By changing the "Input terminal polarity" (FC-01) setting, drive is also allowed when this input terminal is opened.
- An overtravel error (E25) occurs if the servo is ON for more than 1 second after the FOT and ROT were both set to OFF.
- The FOT and ROT terminal function does not change even if the FA-14 (Motor revolution direction) setting is changed. The FOT always prohibits drive in the CCW direction and the ROT prohibits drive in the CW direction.
- When operating the robot with the RDP, the magnetic pole position estimation should be performed with the FOT and ROT set to ON.
- A magnetic pole position estimation error (E95) occurs if either of the FOT or ROT is set to OFF while the magnetic pole position is being estimated.

PEN terminal

The position command pulse input is valid (enabled) only when this signal is ON.

Related parameters

FC-01 : Input terminal polarity setting

- The position command value can be refreshed by pulse train input while this signal is ON.
- The "Input terminal polarity" (FC-01) setting allows position pulse train input to be enabled when this input terminal is opened.

CER terminal

This signal clears the deviation (position error) counter to "0" by setting the position command value as the current position during position control.

Related parameters

FC-01 : Input terminal polarity setting

- This signal is only valid during position control. The position command value is set to the current position value at the instant this signal is switched from OFF to ON. Since this signal turns on at the pulse edge, the counter clearing does not continue even if this signal is kept ON. To clear the counter again, set this signal to OFF and then back ON again.
- By changing the "Input terminal polarity" (FC-01) setting, the deviation counter can also be cleared when this input terminal is opened.

ORG terminal

When servo is ON, tuning this signal ON performs return-to-origin. See 5.4, "Return-to-origin function" for more information.

Related parameters

FA-23: Homing mode
Fb-12: Homing speed 1 (fast)
Fb-13: Homing speed 2 (slow)
FC-01: Input terminal polarity setting

- When return-to-origin is complete, INP turns ON. If this signal is turned OFF before return-to-origin is complete, the movement is interrupted and INP stays OFF.
- Since this signal turns ON at the pulse edge, only one return-to-origin is performed even if this signal is kept ON.

ORL terminal

Use this signal when performing return-to-origin by sensor method. See 5.4, "Return-to-origin function" for more information.
Use this signal only when the connected robot's return-to-origin method is sensor method. No additional wiring is required since the connection to the robot is made via the input/output connector.

Related parameters

FA-23: Homing mode
FC-01: Input terminal polarity setting

5.3 Output terminal functions

Robot driver output terminal functions are described next.
For details on input/output terminal timing chart from the power-on to the position command input, refer to 10.1, “Timing chart”, in Chapter 10.

SRD terminal

This signal is output when the main circuit power is connected and no alarm has tripped. Servo-ON signals can be accepted when this signal is ON, but cannot be accepted if this signal is OFF.

Related parameters
FC-02 : Output terminal polarity setting

- On the RDP, this signal is not output unless magnetic pole position estimation ended correctly. See 5.17, "Magnetic pole position estimation action" for more details.
- By changing the "Output terminal polarity" (FC-02) setting, this output terminal can also be opened when the servo is ready.

ALM terminal

This signal indicates that an alarm has tripped, and can be set to "normally open" or "normally closed" by the "Output terminal polarity setting" (FC-02). (Default setting is "normally closed" contact.) The table below shows the relation between each contact specification and alarm output. When this signal indicates an alarm has tripped, then inputting an alarm reset (RS) or turning the power off and then back on cancels that alarm, and this signal returns to its normal state.

Related parameters
FC-02 : Output terminal polarity setting

Contact specifications	Power OFF	Normal state	Alarm state
Normally closed	OFF	ON	OFF
Normally open	OFF	OFF	ON

INP terminal

This signal indicates that positioning or return-to-origin is complete.

Related parameters
Fb-23 : Positioning detection range
FC-02 : Output terminal polarity setting

- This signal turns OFF when return-to-origin signal is input, and return-to-origin then starts. After return-to-origin is complete, this signal turns ON when the positioning deviation is within the range specified by "Positioning detection range" (Fb-23).
- This signal is OFF when the servo is OFF.
- By changing the "Output terminal polarity" (FC-02) setting, this output terminal can also be opened when positioning is completed.

BRK terminal (relay contact)

This signal is for controlling an externally installed brake.
Use this signal only when the connected robot has a mechanical brake. No additional wiring is required since the connection to the robot is made via the input/output connector.
Two methods of brake signal output are available: output while the motor is stopped and output while the motor is operating. As shown in the table below, each setting can be made to exclude the other setting. Their output methods are described below.

Related parameters

FA-24 : Servo OFF wait time
FA-26 : Brake operation start speed
FA-27 : Brake operation start time
FC-02 : Output terminal polarity setting

Note: In the case of the RDP, this signal cannot be used as a relay output since no relay is mounted on the PC board in the RDP.

Parameter		(1) Brake signal during stop	(2) Brake signal during run
Servo OFF wait time	**FA-24**	Wait time setting	0
Brake operation start speed	**FA-26**	–	Start speed
Brake operation start time	**FA-27**	0	Start time

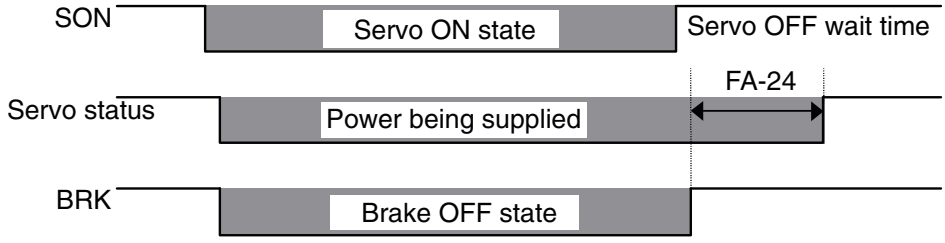
This function will not work correctly unless the exclusive setting is made as shown above.

(1)Brake signal while robot is stopped

In this function, after the brake signal (BRK) has turned on, the servo OFF signal can be delayed in order to counteract delays in the brake operation. So use this signal when the robot stops such as when stopped after positioning. Using this signal frequently while the robot is moving will cause abnormal brake wear.

- This signal turns on simultaneously with servo ON operation when a servo-ON signal is input. This signal immediately turns off when the servo ON signal turns off. The servo then turns off after a time preset by the "Servo OFF wait time" (FA-24) parameter has elapsed. (See figure below.)
- The "Servo OFF wait time" (FA-24) can be set from 0 to 1.00 seconds in 10ms steps, and operation may have a maximum delay of 1ms.
- If an alarm trips then the servo turns off simultaneously with this signal.
- By changing the "Output terminal polarity" (FC-02) setting, this output terminal can also be opened when the brake is released.
- When using this function, set the "Brake operation start time" (FA-27) to 0.

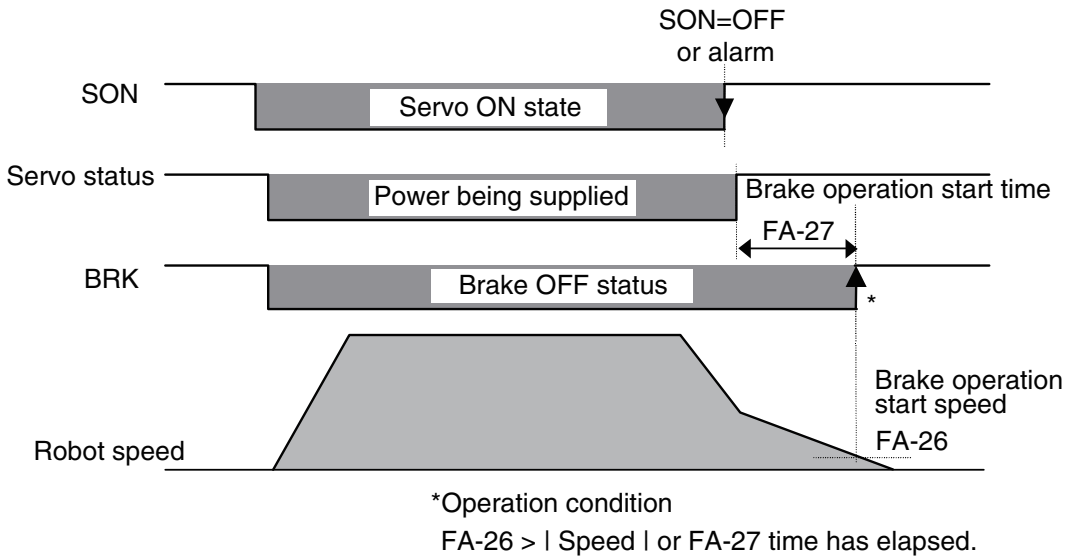
Note: Operation is controlled by pulse train input even during the "Servo OFF wait time". To stop the operation, turn off the PEN input or stop the pulse train input.



(2)Brake signal while robot is operating

This function is used when applying the brake while the robot is operating so use in applications where the robot can slow sufficiently such as when the robot is free-running. Using this function when moving a heavy payload may cause braking delays, resulting in dropping hazards so use caution.

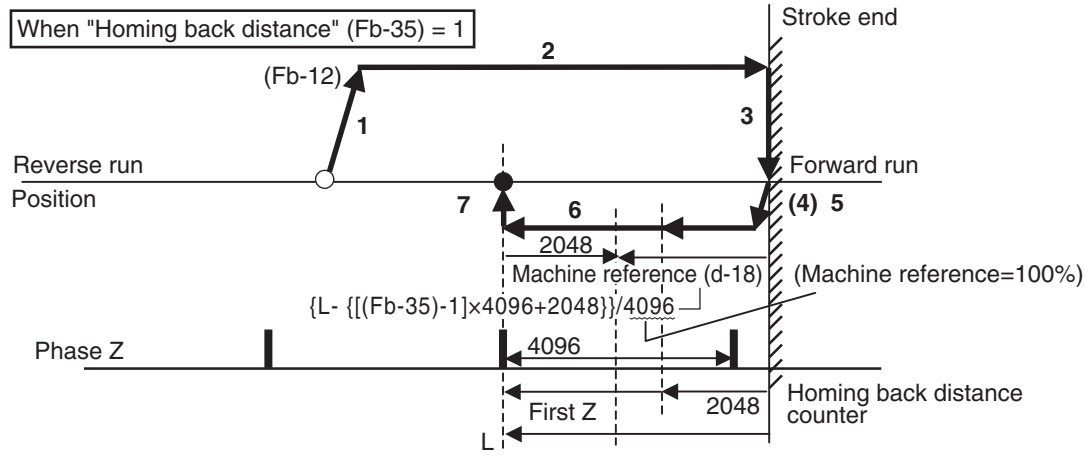
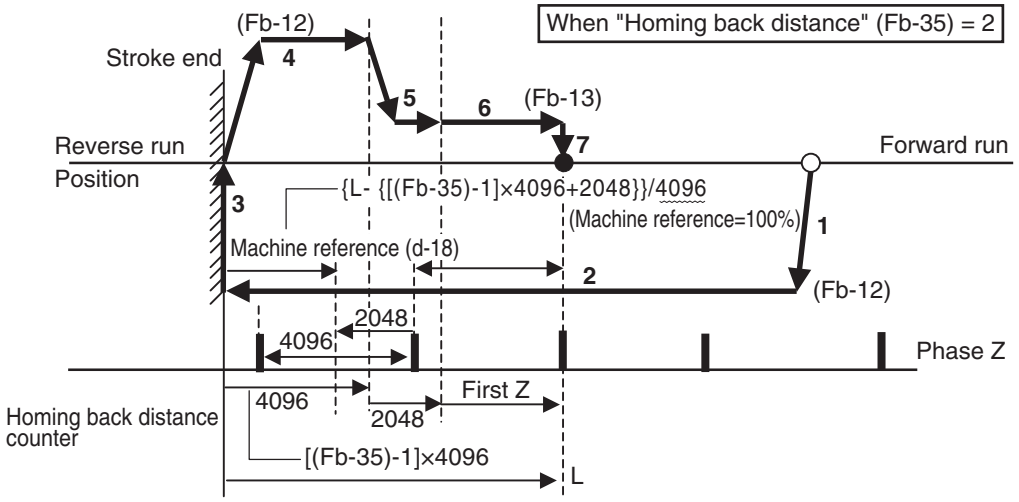
- This signal turns on simultaneously with servo ON operation when a servo-ON signal is input. Also, when the servo turns off or an alarm trips, the brake is applied when the robot speed falls below the "Brake operation start speed" (FA-26) or after the "Brake operation start time" (FA-27) has elapsed after the servo turns off. (See figure below.)
- The "Brake operation start time" (FA-27) can be set from 0 to 1.000 second in 4ms steps, and operation may have a maximum delay of 1ms.
- By changing the "Output terminal polarity" (FC-02) setting, this output terminal can also be opened when the brake is released.
- When using this function, set the "Servo OFF wait time" (FA-24) to 0.



5.4 Return-to-origin function

(1)Return-to-origin using stroke end method (RDX)

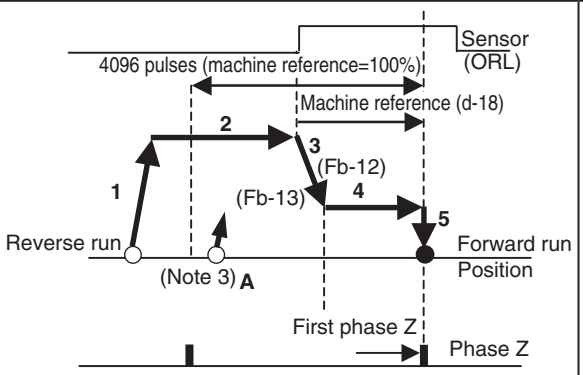
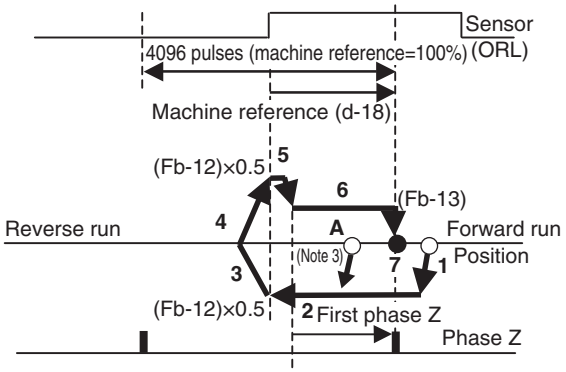
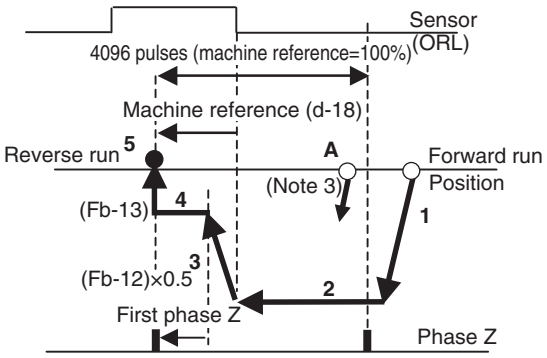
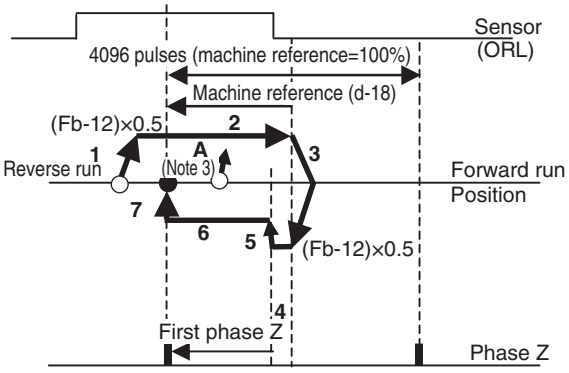
The following table shows the RDX return-to-origin operation using the stroke end method.

FA-23	Return-to-origin using stroke end method
t-F	
t-r	
Operation sequence	1. Start return-to-origin. 2. Robot moves towards stroke end at return-to-origin speed (Fb-12). 3. Reverses movement direction while adjusting speed during acceleration/deceleration time (Fb-04, Fb-05) when the robot has reached the stroke end, which is determined by detecting (in first part of this step) a motor current exceeding the rated current and then the specified "Stroke-end current" (Fb-36). (Note 1) 4. Moves in direction opposite the stroke end at return-to-origin speed (Fb-12). Starts counting the Homing back distance from the stroke end. (If the "Homing back distance" (Fb-35) is set to 1, then step 4 is skipped and goes to step 5.) 5. When the Homing back distance count exceeds "[(Fb-35) – 1] × 4096" pulses, the robot starts slowing down during deceleration time (Fb-05) and moves at slow return-to-origin speed (Fb-13). (Note 1) 6. Continues moving at slow return-to-origin speed (Fb-13). 7. Stops at first "phase Z" position after the Homing back distance count has exceeded "[(Fb-35) – 1] × 4096+2048" pulses. (Machine reference is displayed on d-18, which is calculated as follows: { L (distance from stroke end to stop point)–{[(Fb-35) – 1]× 4096+2048}} / 4096)

Note 1: The acceleration/deceleration time parameters specify the time needed to accelerate or decelerate between 0 and maximum speed.

(2)Return-to-origin using sensor method (RDX)

The following table shows the RDX return-to-origin operation using the sensor method.

FA-23	ORL terminal at start of return-to-origin using sensor method	
	OFF	ON
S-F		
S-r		
Operation sequence	1. Start return-to-origin. 2. Robot moves towards origin at return-to-origin speed (Fb-12). 3. Slows down during deceleration time (Fb-05) when sensor (ORL terminal) turns on. (Note 5) 4. Continues moving at slow return-to-origin speed (Fb-13). 5. Stops at first "phase Z" position after reaching the slow return-to-origin speed (Fb-13). (Machine reference displayed on d-18.) (Note 3)	1. Start return-to-origin. 2. Robot moves away from origin at 50% of return-to-origin speed (Fb-12). 3. Reverses movement direction when sensor (ORL terminal) turns off. (Deceleration/acceleration time is determined by parameters (Fb-05, Fb-04). (Note 5) 4. Moves back towards origin at 50% of return-to-origin speed (Fb-12). (Note 4) 5. Slows down during deceleration time (Fb-05) when sensor (ORL terminal) turns on. (Note 5) 6. Continues moving at slow return-to-origin speed (Fb-13). 7. Stops at first "phase Z" position after reaching the slow return-to-origin speed (Fb-13). (Machine reference displayed on d-18.) (Note 3)

Note 1:If the origin sensor (ORL terminal) does not turn off even when the robot has moved a distance of 50,000 pulses after starting return-to-origin with the origin sensor (ORL terminal) turned on (operation in steps 1 and 2), then an origin sensor alarm (E80) occurs.

Note 2:If the origin sensor (ORL terminal) does not turn on and the robot comes into contact with the mechanical end (stroke end), then an overload alarm (E05) occurs.

Note 3:Machine reference is displayed after return-to-origin is completed normally.

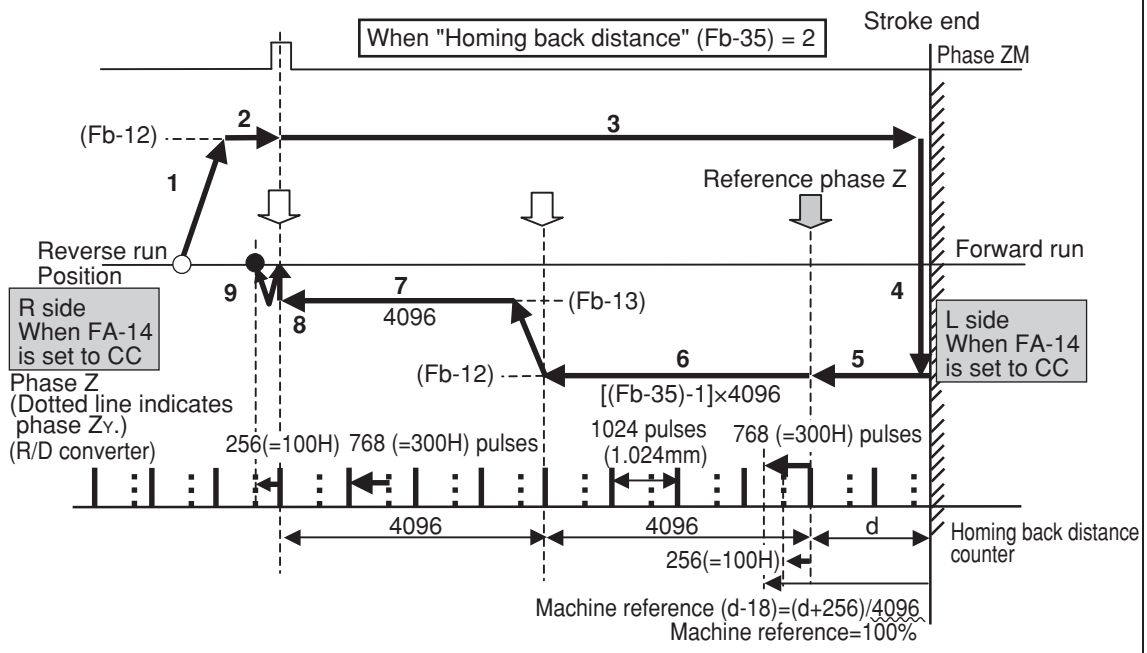
Note 4:If the origin sensor (ORL terminal) turns on during acceleration, then the robot immediately slows down and sets to step 5. (Speed might not always reach 50% of return-to-origin speed (Fb-12)).

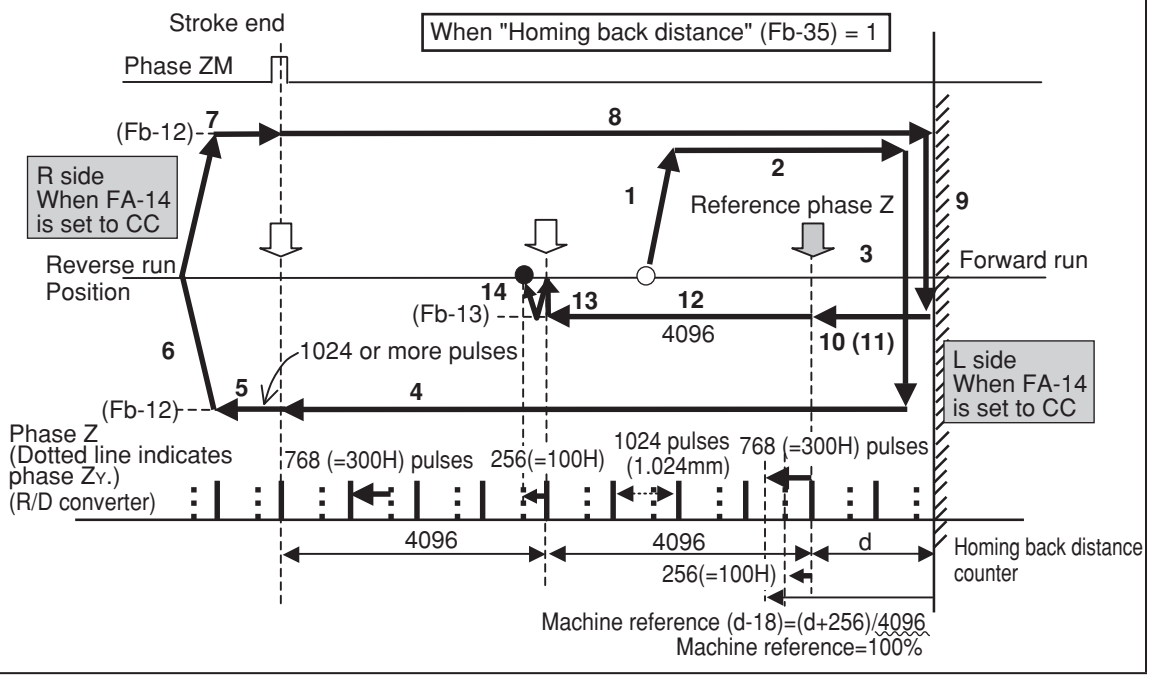
Note 5:Acceleration/deceleration time parameters set the time needed to accelerate or decelerate between 0 and maximum speed.

(3)Return-to-origin using stroke end method (RDP)

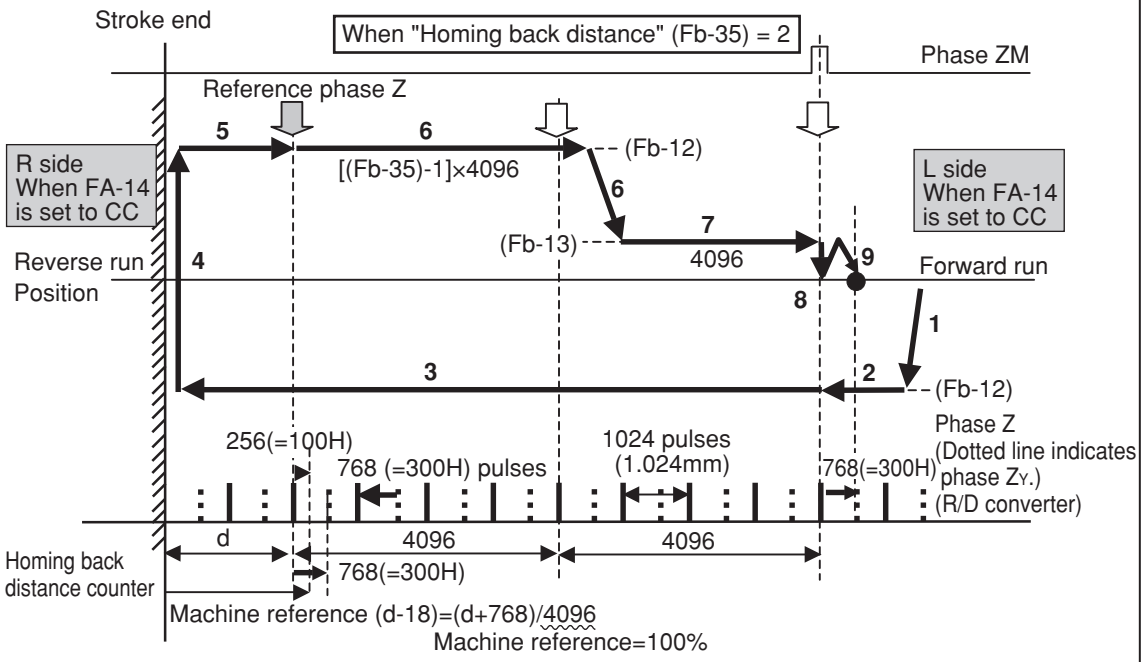
The following table shows the RDP return-to-origin operation using the stroke end method.

FA-23	Return-to-origin using stroke end method
	When phase ZM is between return-to-origin start position and stroke end
t-F	**When return-to-origin start position is between phase ZM is and stroke end**

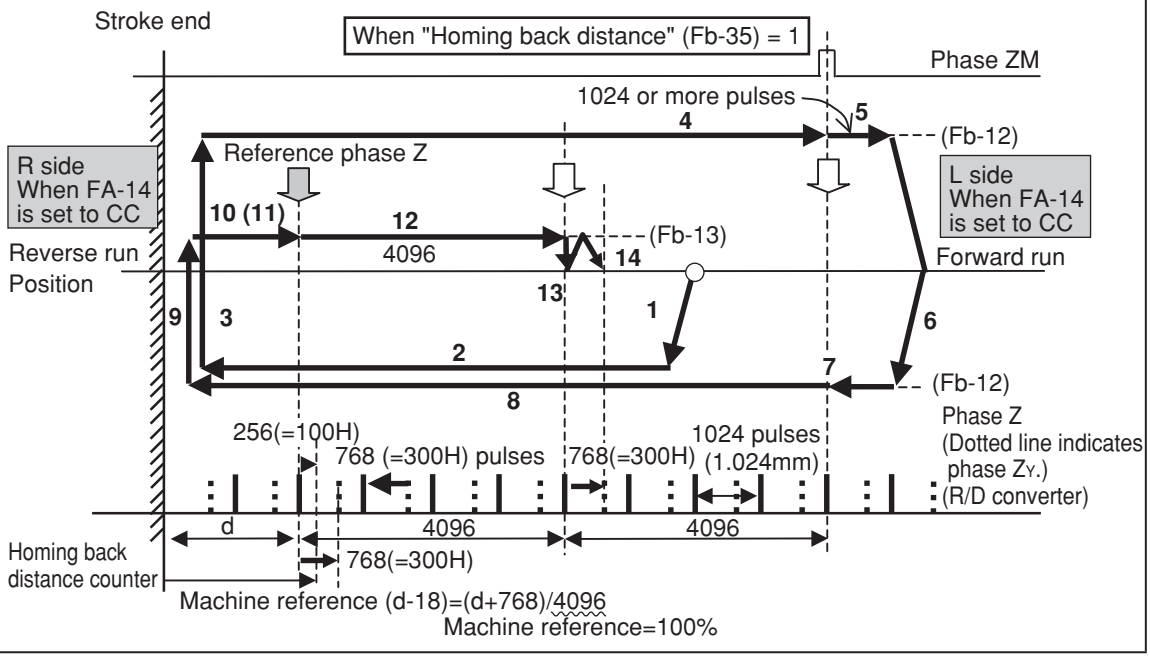




FA-23	Return-to-origin using stroke end method
t-r	**When phase ZM is between return-to-origin start position and stroke end**



When return-to-origin start position is between phase ZM and stroke end

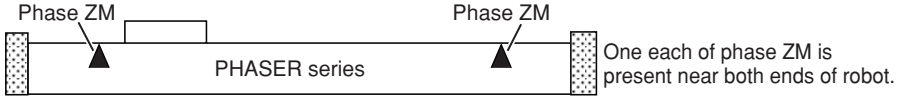


FA-23	Return-to-origin using stroke end method	
	When phase ZM is between return-to-origin start position and stroke end	**When return-to-origin start position is between phase ZM is and stroke end**
Operation sequence	1. Start return-to-origin. 2. Robot moves towards stroke end at return-to-origin speed (Fb-12). 3. Continues moving towards the stroke end at return-to-origin speed (Fb-12). Starts counting "Homing back distance" after detecting the sensor signal (phase ZM). Among phase Z at each 4096 count, the phase Z detected at a point closest to the stroke end is regarded as reference phase Z. 4. Reverses movement direction while adjusting speed during acceleration/deceleration time (Fb-04, Fb-05) when robot has reached the stroke end, which is determined by detecting (in first part of this step) a motor current that exceeded the rated current and then the specified stroke-end current. 5. Moves in direction opposite the stroke end at return-to-origin speed (Fb-12). 6. Continues moving in direction opposite the stroke end until reaching the position "[(Fb-35)–1] × 4096]" pulses away from the reference phase Z. (If "Homing back distance" (Fb-35) is set to 1, then step 6 is skipped and goes to step 7.) 7. Moves at slow return-to-origin speed (Fb-13) after adjusting speed during deceleration time (Fb-05). (Note 1) 8. Temporarily stops at a position 4096 pulses away from phase Z at the deceleration point. 9. Further moves a distance equal to the following phase difference between phase Z_Y and phase Z, and then stops there. When moving to L: 256=100H pulses When moving to R: 768=300H pulses Machine reference is displayed on d-18, which is calculated as follows: When moving to L: (d-18)=(d+768)/4096 When moving to R: (d-18)=(d+256)/4096	1. Start return-to-origin. 2. Robot moves towards stroke end at return-to-origin speed (Fb-12). 3. Reverses movement direction while adjusting speed during acceleration/deceleration time (Fb-04, Fb-05) when robot has reached the stroke end, which is determined by detecting (in first part of this step) a motor current that exceeded the rated current and then the specified stroke-end current (Fb-36). (Note 1) 4. Moves in direction opposite the stroke end at return-to-origin speed (Fb-12). 5. Moves a distance of 1024 pulses after detecting the sensor signal (phase ZM). 6. Reverses movement direction while adjusting speed during deceleration time (Fb-05) after checking that at least 1024 pulses have elapsed. (Note 1) 7. Moves towards the stroke end after changing speed back to the return-to-origin speed (Fb-12) during acceleration time (Fb-04). 8. Continues moving towards the stroke end at return-to-origin speed (Fb-12). Starts counting the "Homing back distance" after detecting the sensor signal (phase ZM). Among phase Z at each 4096 count, the phase Z detected at a point closest to the stroke end is regarded as reference phase Z. 9. Reverses movement direction while adjusting speed during acceleration/deceleration time (Fb-04, Fb-05) when the robot has reached the stroke end, which is determined by detecting (in first part of this step) a motor current that exceeded the rated current, and then the specified stroke-end current. 10. Moves in direction opposite the stroke end at return-to-origin speed (Fb-12). 11. Continues moving in direction opposite the stroke end until reaching the position "[(Fb-35)–1] × 4096]" pulses away from the reference phase Z. (If "Homing back distance" (Fb-35) is set to 1, then step 11 is skipped and goes to step 12.) 12. Moves at slow return-to-origin speed (Fb-13) after adjusting speed during deceleration time (Fb-05). (Note 1) 13. Temporarily stops at a position 4096 pulses away from phase Z at the deceleration point. 14. Further moves a distance equal to the following phase difference between phase Z_Y and phase Z, and then stops there. When moving to L: 256=100H pulses When moving to R: 768=300H pulses Machine reference is displayed on d-18, which is calculated as follows: When moving to L: (d-18)=(d+768)/4096 When moving to R: (d-18)=(d+256)/4096

Note 1: The acceleration/deceleration time parameters specify the time needed to accelerate or decelerate between 0 and maximum speed.

Note 2: There are two phase Z types as described below. Be careful not to confuse them.

Phase ZM : Phase Z signal that is input from the mechanical section via ENC. (This sensor signal is output from two points at both ends of the mechanical stroke.)



Phase Z (R/D converter) : Phase Z signal that is output from the resolver or R/D converter. (This is output every 1024 pulses.)
Also note that the ORL terminal is left unconnected when performing the RDP return-to-origin operation using the stroke end method.

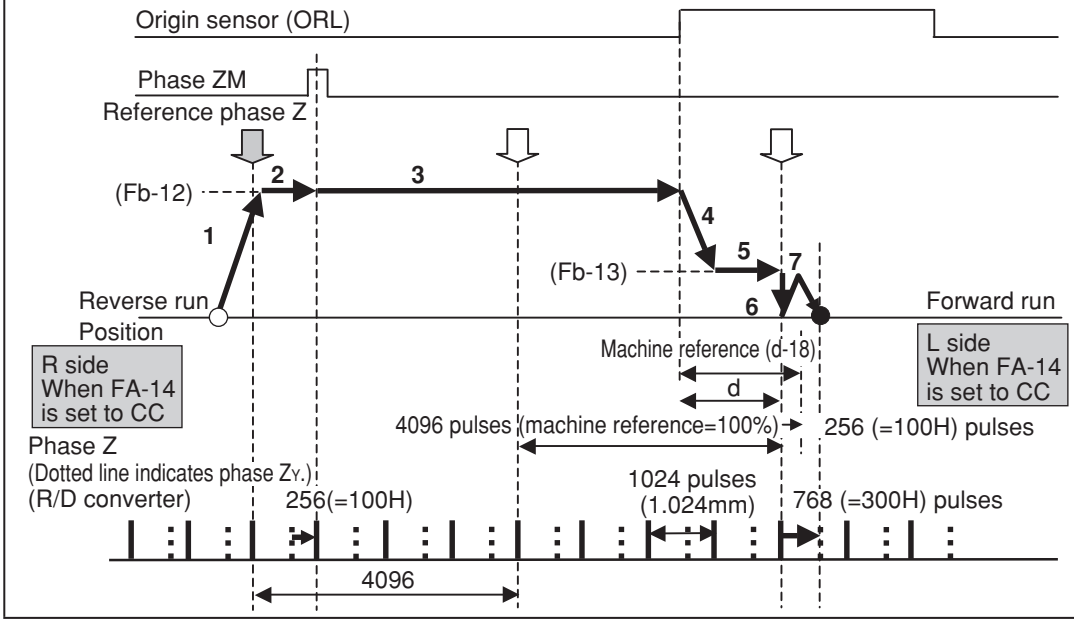
Note 3: Phase Z_Y is a position offset 768(=300H) pulses from the phase Z (R/D converter) signal.
Machine reference corresponds to the distance between the stroke end and phase Z_Y as shown in the operation sequence diagram.

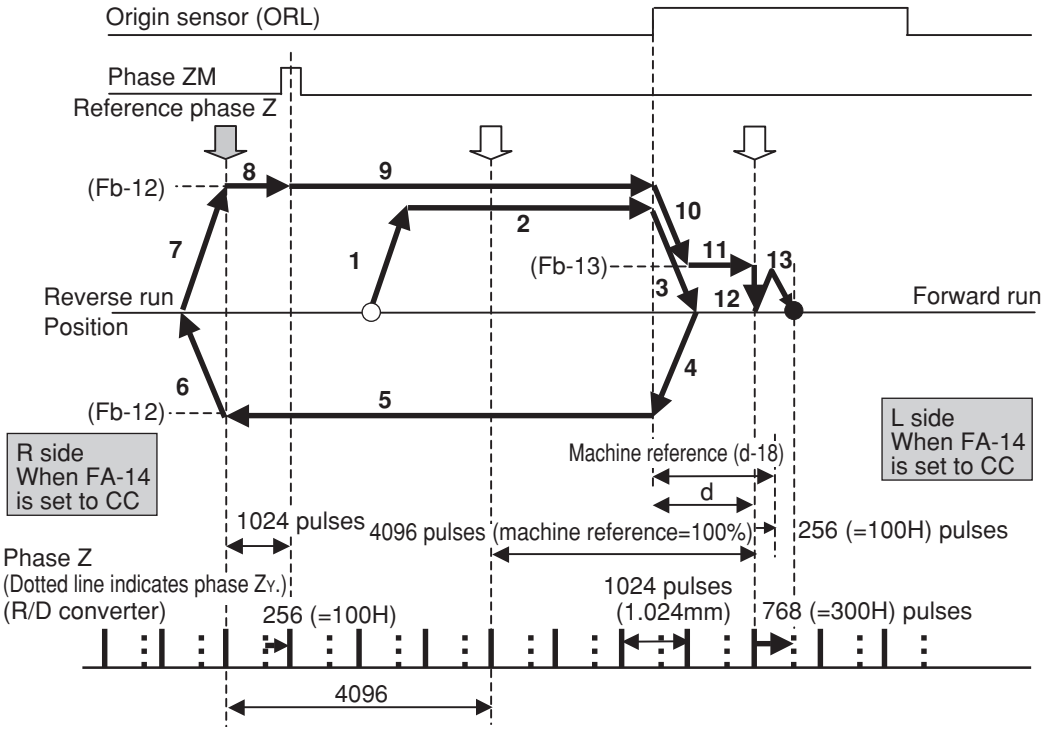
Note 4: The magnetic pole position is determined when phase ZM is passed.

(4)Return-to-origin using sensor method (RDP)

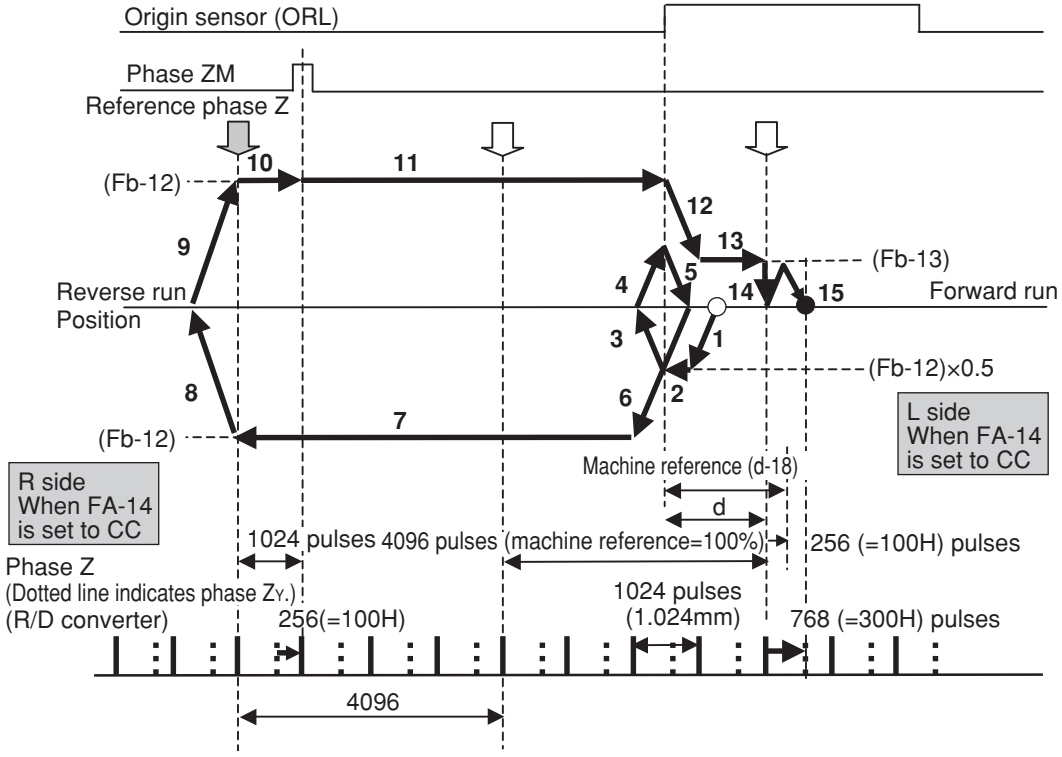
The following table shows the RDP return-to-origin operation using the sensor method.

FA-23	Return-to-origin using sensor method
S-F	When phase ZM is between return-to-origin start position and origin sensor
	When return-to-origin start position is between phase ZM is and origin sensor



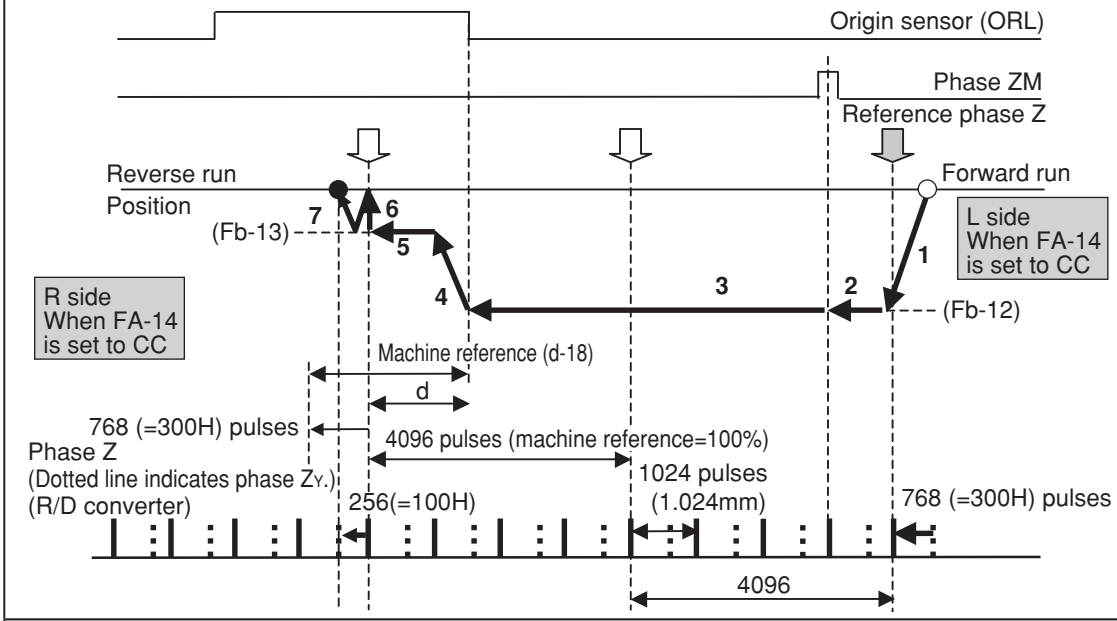


FA-23	Return-to-origin using sensor method
S-F	When origin sensor is ON when starting return-to-origin

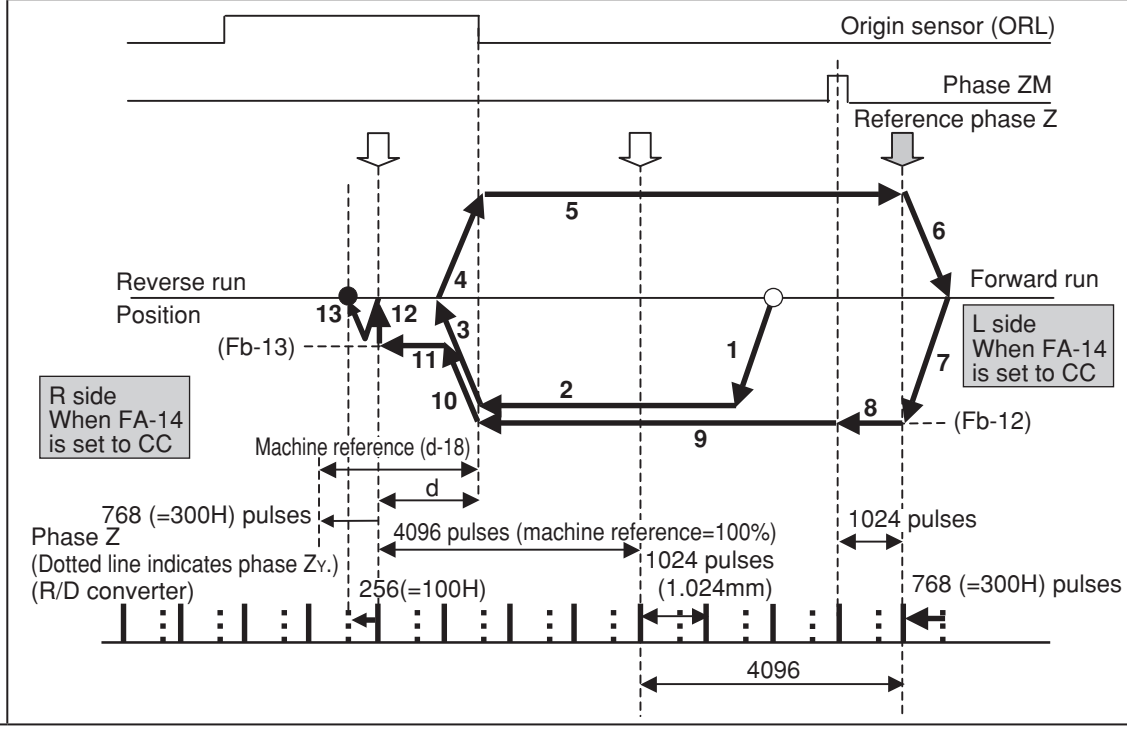


Operating direction (as viewed from cable carrier side of robot)	FA-14	
	CC	C
Forward run	Slider moves to L side	Slider moves to R side
Reverse run	Slider moves to R side	Slider moves to L side

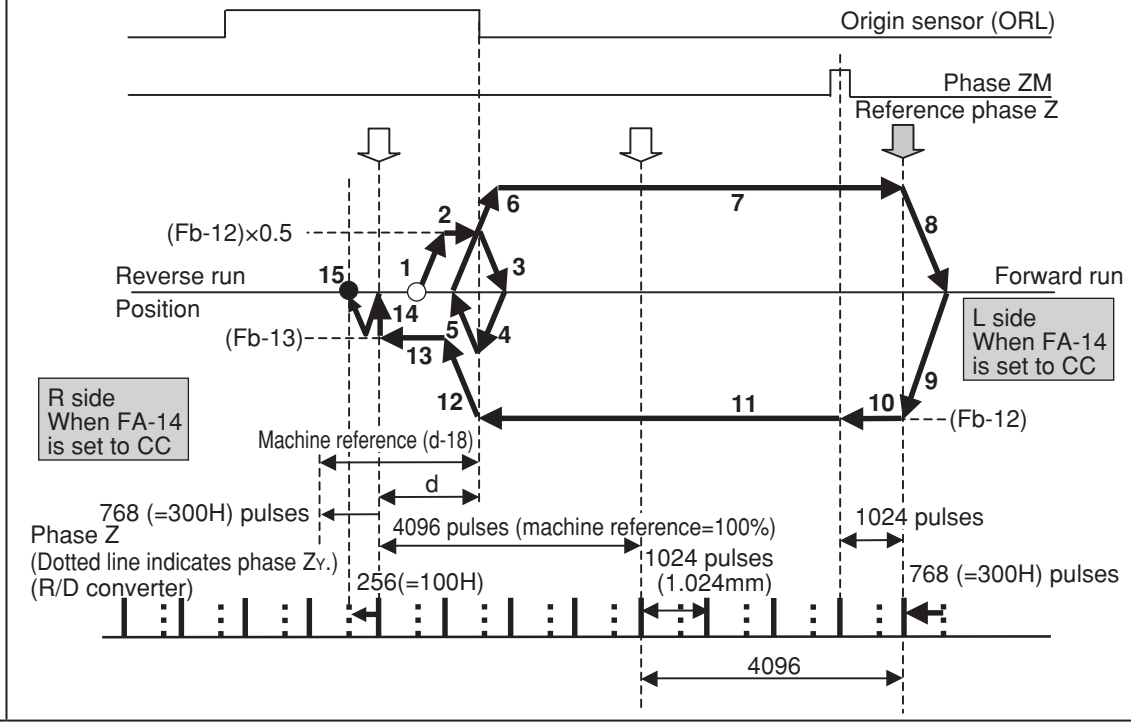
FA-23	Return-to-origin using sensor method
S-r	When phase ZM is between return-to-origin start position and origin sensor



S-r	When return-to-origin start position is between phase ZM is and origin sensor



FA-23	Return-to-origin using sensor method
S-r	When origin sensor is ON when starting return-to-origin



Operating direction (as viewed from cable carrier side of robot)	FA-14	
	CC	C
Forward run	Slider moves to L side	Slider moves to R side
Reverse run	Slider moves to R side	Slider moves to L side

FA-23	Return-to-origin using sensor method
Operation sequence	**When phase ZM is between return-to-origin start position and origin sensor**
	1. Start return-to-origin. 2. Robot moves at return-to-origin speed (Fb-12). 3. Continues moving at return-to-origin speed (Fb-12). Starts detecting phase Z at each 4096 count after detecting the sensor (phase ZM) signal. At this point, phase Z just before detecting the sensor (phase ZM) signal is regarded as reference phase Z which is the start point to detect phase Z at each 4096 count. 4. Slows down during deceleration time (Fb-05) after detecting that the origin sensor (ORL terminal) has turned on. (Note 2) 5. Moves at slow return-to-origin speed (Fb-13). 6. After detecting the origin sensor signal, the robot temporarily stops at first "phase Z" position detected at each 4096 count. 7. Further moves a distance equal to the phase difference between phase Z_Y and phase Z, and then stops there. When moving to L: 256=100H pulses When moving to R: 768=300H pulses Machine reference is displayed on d-18, which is calculated as follows: When moving to L: (d-18)=(d+768)/4096 When moving to R: (d-18)=(d+256)/4096
	When return-to-origin start position is between phase ZM is and origin sensor
	1. Start return-to-origin. 2. Robot moves at return-to-origin speed (Fb-12). 3. Slows down during deceleration time (Fb-05) after detecting that the origin sensor (ORL terminal) has turned on. (Note 2) 4. Reverses movement direction after the motor has stopped, and speeds up during acceleration time (Fb-04). 5. Moves at return-to-origin speed (Fb-12) until 1024 pulses have elapsed after detecting the sensor (phase ZM) signal. 6. Slows down during deceleration time (Fb-05). 7. Reverses movement direction after the motor has stopped, and speeds up during acceleration time (Fb-04). 8. Moves at return-to-origin speed (Fb-12). 9. Continues moving at return-to-origin speed (Fb-12). Starts detecting phase Z at each 4096 count after detecting the sensor (phase ZM) signal. At this point, phase Z just before detecting the sensor (phase ZM) signal is regarded as reference phase Z which is the start point to detect phase Z at each 4096 count. 10. Slows down during deceleration time (Fb-05) after detecting that the origin sensor (ORL terminal) has turned on. (Note 2) 11. Moves at slow return-to-origin speed (Fb-13). 12. After detecting the origin sensor signal, the robot temporarily stops at first "phase Z" position detected at each 4096 count. 13. Further moves a distance equal to the phase difference between phase Z_Y and phase Z, and then stops there. When moving to L: 256=100H pulses When moving to R: 768=300H pulses Machine reference is displayed on d-18, which is calculated as follows: When moving to L: (d-18)=(d+768)/4096 When moving to R: (d-18)=(d+256)/4096

FA-23	Return-to-origin using sensor method
Operation sequence	**When origin sensor is ON when starting return-to-origin**

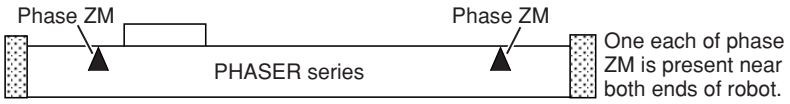
1. Start return-to-origin.
2. Robot moves at 50% of return-to-origin speed (Fb-12).
3. Slows down during deceleration time (Fb-05) after detecting that the origin sensor (ORL terminal) has turned off. (Note 2)
4. Reverses movement direction after the motor has stopped, and speeds up during acceleration time (Fb-04). Then moves at 50% of return-to-origin speed (Fb-12).
5. Slows down during deceleration time (Fb-05) after detecting that the origin sensor (ORL terminal) has turned on. (Note 2)
6. Reverses movement direction after the motor has stopped, and speeds up during acceleration time (Fb-04). Then moves at return-to-origin speed (Fb-12).
7. Continue moving at return-to-origin speed (Fb-12) until 1024 pulses have elapsed after detecting the sensor (phase ZM) signal.
8. Slows down during deceleration time (Fb-05).
9. Reverses movement direction after the motor has stopped, and speeds up during acceleration time (Fb-04).
10. Moves at return-to-origin speed (Fb-12).
11. Continues moving at return-to-origin speed (Fb-12). Starts detecting phase Z at each 4096 count after detecting the sensor (phase ZM) signal.
    At this point, phase Z just before detecting the sensor (phase ZM) signal is regarded as reference phase Z which is the start point to detect phase Z at each 4096 count.
12. Slows down during deceleration time (Fb-05) after detecting that the origin sensor (ORL terminal) has turned on. (Note 2)
13. Moves at slow return-to-origin speed (Fb-13).
14. After detecting the origin sensor signal, the robot temporarily stops at first "phase Z" position detected at each 4096 count.
15. Further moves a distance equal to the phase difference between phase Z_Y and phase Z, and then stops there.
    When moving to L: 256=100H pulses
    When moving to R: 768=300H pulses
    Machine reference is displayed on d-18, which is calculated as follows:
    When moving to L: (d-18)=(d+768)/4096
    When moving to R: (d-18)=(d+256)/4096

Note 1: The acceleration/deceleration time parameters specify the time needed to accelerate or decelerate between 0 and maximum speed.

Note 2: If the origin sensor (ORL terminal) does not turn on and the robot comes into contact with the mechanical end (stroke end), then an overload alarm (E05) occurs.

Note 3: There are two phase Z types as described below. Be careful not to confuse them.

Phase ZM : Phase Z signal that is input from the mechanical section via ENC. (This sensor signal is output from two points at both ends of the mechanical stroke.)



Phase Z (R/D converter): Phase Z signal that is output from the resolver or R/D converter. (This is output every 1024 pulses.)

Note 4: Phase Z_Y is a position offset 768(=300H) pulses from the phase Z (R/D converter) signal.

Note 5: Connect the origin sensor to the ORL terminal.

Note 6: If the origin sensor (ORL terminal) does not turn off even when the robot has moved a distance of 50,000 pulses after starting return-to-origin with the origin sensor (ORL terminal) turned on, then an origin sensor alarm (E80) occurs.

Note 7: The magnetic pole position is determined when phase ZM is passed.

5.5 Analog output function

The robot driver has 2 channels provided with analog monitor output terminals. The output voltage is from 0 to ±3.0V. The speed detection value (nFb), torque command value (tqr), speed command value (nrF), speed deviation (nEr), position deviation (PEr), current value (iFb), command pulse frequency (PFq), and regenerative braking resistor duty ratio (brd) can be selected with parameters (FC-30, FC-33) on the monitor terminals AO1, AO2 (common L terminal) for the 2 channels. The monitor output gain can be set in FC-32 and FC-35. The positive/negative polarity output (0 to ±3.0V) or the absolute value output (0 to ±3.0V) can be selected with FC-31 and FC-34.

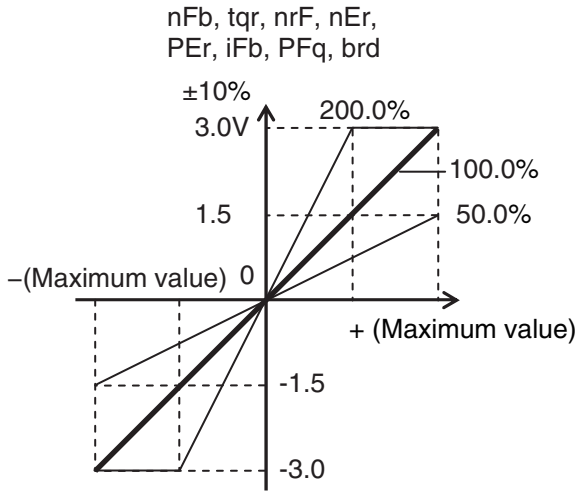
Analog monitor output function

Setting	Data name	Maximum monitor output value (3.0V output value) (Note 1)	Monitor output 1, 2 gain setting range (%) (FC-32)(FC-35)
nFb	Speed detection value	Maximum speed	0 to 3000.0 (Default: 100%)
tqr	Torque command value	Maximum torque	
nrF	Speed command value	Maximum speed	
nEr	Speed deviation	Maximum speed	
PEr	Position deviation	5 rotations of motor	
iFb	Current value	Maximum current	
PFq	Command pulse frequency	Maximum speed	
brd	Regenerative braking resistor duty ratio	Alarm level (FA-08)	

Note 1: Monitor output is 3.0V as in the above table when the monitor output gain is 100%.

Note 2: Output signal accuracy is within ±10%.

Note 3: Set the monitor output data for an output of 0 to ±3.0V, or 0 to 3.0V in FC-31 and FC-34. However, "PFq" and "brd" are only positive outputs.

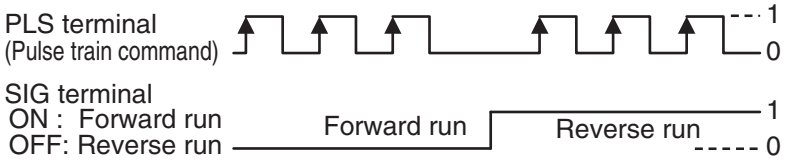
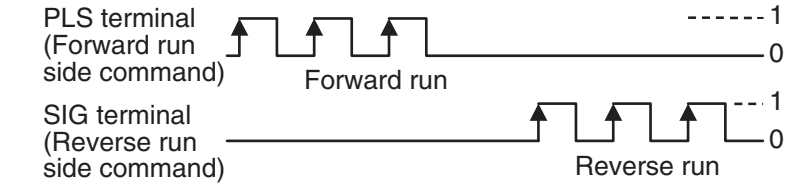
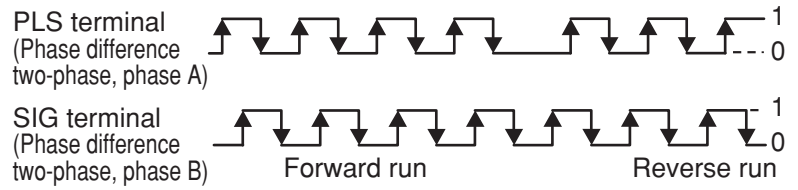
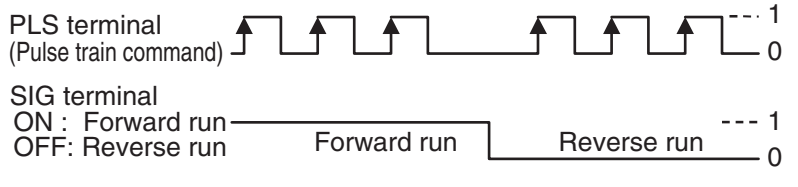
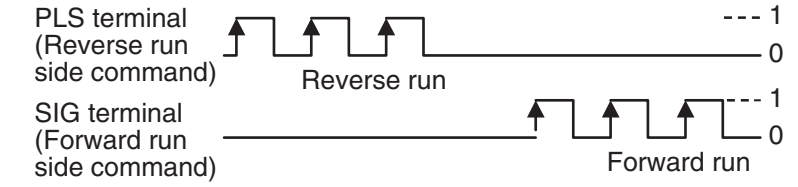
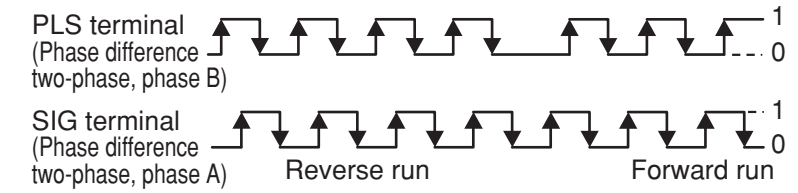


Gain setting for monitor outputs 1, 2
(FC-32), (FC-35)

5.6 Pulse train input function

(1)Position pulse train input

The pulse train signals (PLS, SIG) for the position command are valid in position control mode. Position commands from this signal are counted only when the pulse train input enable signal (PEN) is ON. There are 6 position command count modes as shown in the table below and these are set by the parameter (FA-11).

FA-11	Signal name	Pulse train input
P-S (Default)	Pulse train command	
F-r	Forward/ Reverse run pulse	
A-b	Phase difference two-phase pulse	 **[* Count is multiplied by 4.]**
-P-S	Reverse pulse train command	
r-F	Reverse/ Forward run pulse	
b-A	Reverse phase difference two-phase pulse	 **[* Count is multiplied by 4.]**

The "Command pulse filter time constant" (FC-19) parameter for the pulse train input circuit hardware can be selected by the command pulse frequency.

Command pulse filter time constant FC-19	Filter time constant (μs)	Recommended command pulse frequency
Lo	1	Less than 200k pulses/s
Hi (default setting)	0.2	More than 200k pulses/s

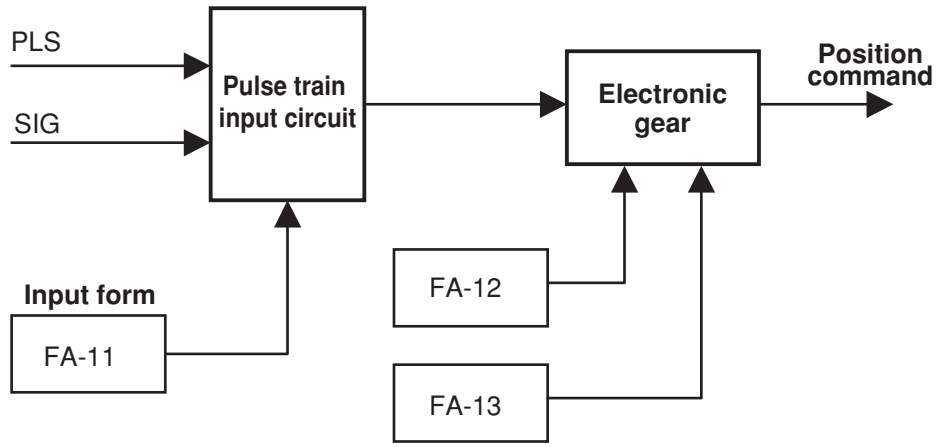
Note: When using phase difference two-phase pulse (A, B phase input), the recommended input frequency is 1/4 of the frequency value in the above table.

(2) Electronic gear

Position commands input by pulse train signals are processed in the electronic gear and become the position command value. This electronic gear multiples the input command value by (FA-12/FA-13) to form the position command value. That relation is shown in the following formula.

$$\text{(Position command value)} = \frac{\text{(Electronic gear numerator FA-12)}}{\text{(Electronic gear denominator FA-13)}} \times \text{(Pulse train input)}$$

The pulse train input is summarized in the following figure.



Note: The FLIP-X series resolution is 16384 pulses per revolution of the motor.
The PHASER series resolution is 1 pulse per micrometer.

[Calculation examples of electronic gear ratio]

1. To move the MR16 (PHASER series) robot at a speed of 2000 millimeters per second [mm/s] with input pulses at a frequency of 500kpps:

Here, by setting the resolution [mm/pulse] as a, the input frequency [pps] as P, the movement speed [mm/s] as V, and the electronic gear ratio as G (=FA-12/FA-13), V can then be expressed as follows.

$$V = G \times (P \times a) \quad (1)$$

Since the PHASER series resolution is 1µm and since a=0.001 [mm/pulse] then by applying formula (1) we obtain:

G = 4

So setting an electronic gear ratio of FA-12 : FA-13 = 4 : 1 allows robot movement at a speed of 2000 [mm/s].

2. To move the F14-20 (FLIP-X series) robot a distance of 1 µm per pulse:

Here, by setting the resolution [mm/pulse] as a, the lead length [mm/rev] as L, and pulses per motor revolution [pulses/rev] as n, and the electronic gear ratio as G (=FA-12/FA-13), the resolution a can then be expressed as follows.

$$a = L / n \quad (2)$$

To move the robot 0.001mm per pulse, an electronic gear ratio G that satisfies the following relation is needed.

$$0.001 = G \times a \quad (3)$$

On the F14-20 robot, L=20 [mm/rev] and n=16384 [pulses/rev], so by applying formulas (2) and (3) we obtain:

G = 16384 / 20000

So setting an electronic gear ratio of FA-12 : FA-13 = 16384 : 20000 allows robot movement at 1µm per pulse.

Note 1: When the position pulse train signal type is phase difference 2-phase pulse, the electronic gear ratio should be calculated using the input frequency multiplied by 4.

Note 2: Do not set a frequency or electronic gear ratio that exceeds the maximum robot speed.

Note 3: Operation cannot be guaranteed when the electronic gear is set to an extreme value. Make sure that the setting (FA-12/FA-13) is in a range from 1/20 to 50.

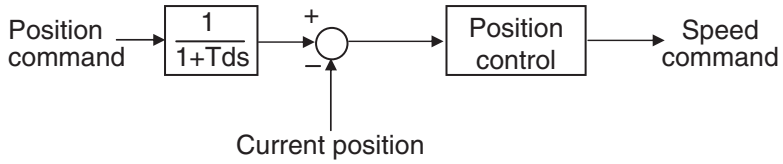
5.7 Smoothing function

(1)Position command filter

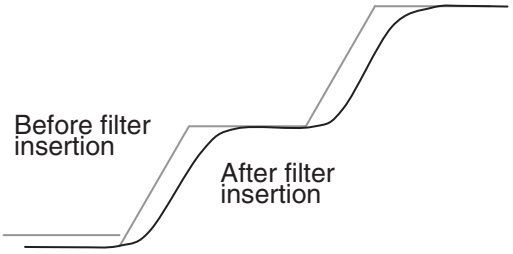
The command pulse rate may cause vibrations when used in combination with a low-rigidity machine. To prevent this vibration, a filter is added to the position command so that commands can be changed smoothly.
The filter time constant can be set by parameter (Fd-36). Setting the parameter to 0 disables this function.

Parameter	Function name	Description	Default setting
Fd-36	Position command filter time constant	Inserting a filter makes the position command run smoothly. 0 to 60000ms, 0 = Invalid	0

This function is only valid during position control. The control block is shown below.



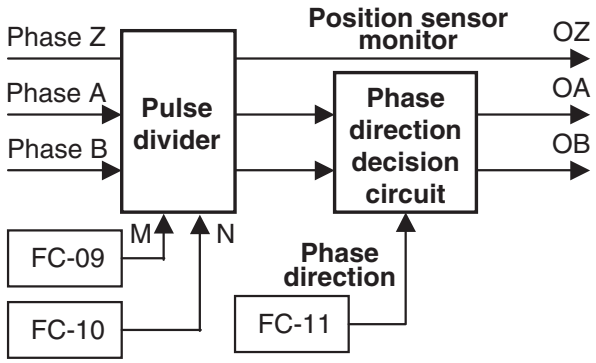
Inserting a filter makes the position command run smoothly as shown in the figure below and vibration can be prevented.



Note 1: In position control mode, always set Fd-36 to 0 during unlimited feed in one way direction, or during synchronous operation of units such as the conveyor in one way direction. Unless Fd-36 is set to 0, a position deviation error (E83) will occur.

5.8 Position sensor monitor function

The position sensor monitor signals OA and OB, which are obtained by dividing the position sensor "phase A" and "phase B" signals, are output as a line driver output. The "phase Z" signal is directly output as OZ as a line driver output and an open collector output.
The position sensor monitor signal is processed by a pulse divider whose division ratio M/N can be set by the "Position sensor monitor resolution M, N" (FC-09), (FC-10). The division ratio can be 1/N (N=1 to 64), 2/N (N=3 to 64) or M/8192 (M=1 to 8191). (Note 3) If the division ratio M/N is set in an invalid combination, then no position sensor monitor signal is output and a mismatch error (E40) occurs. The OZ signal of phase Z is not divided here. On the FLIP-X series, 1 pulse is output per 1/4 of revolution. On the PHASER series, an output occurs when the robot passes through phase ZM near both ends of the robot.
The "phase Z" signal of the position sensor transits the internal circuits within the robot driver and is output as is (unchanged). Regarding the phase difference between the OA and OB signals of phase A and phase B and the direction the robot moves, phase B leads phase A (default setting) during forward run. But this can be changed by setting the parameter (FC-11) so that phase A leads phase B.



M/N setting range		Position sensor monitor division ratio	Invalid combination
M	N		
FC-09	FC-10		
1 (Note 1)	1 to 64	1/N	FC-10 = 65 to 8192
2 (Note 1)	3 to 64	2/N	FC-10 = 1, 2, 65 to 8192
1 to 8191	8192 (Note 1)	M/8192	FC-09 = 8192 FC-10 = 1 to 8191

Note 1: The position sensor monitor division ratio is M/8192 in the case of FC-10 = 8192. When FC-10 is not 8192 then the position monitor sensor division ratio to set to 1/N or 2/N according to the FC-09 setting.

Note 2: If FC-09, FC-10 or FC-11 was changed then turn the control power supply off and then back on again. The correct waveform is not output unless the power is turned off and then back on.

Note 3: The position sensor monitor output signals OAP, OAN, OBP, OBN, OZP, OZN and OZ are not available for about 3 seconds after the control power supply is turned on. If monitoring from a master control device then start monitoring from about 3 seconds after turning on the control power supply.

The logic output for each signal is as follows.

Logic	Current path of line driver output (OAP, OAN, OBP, OBN, OZP, OZN)	Open collector output Transistor operation (OZ)
1	OAP → OAN OBP → OBN OZP → OZN	ON (closed)
0	OAP ← OAN OBP ← OBN OZP ← OZN	OFF (open)

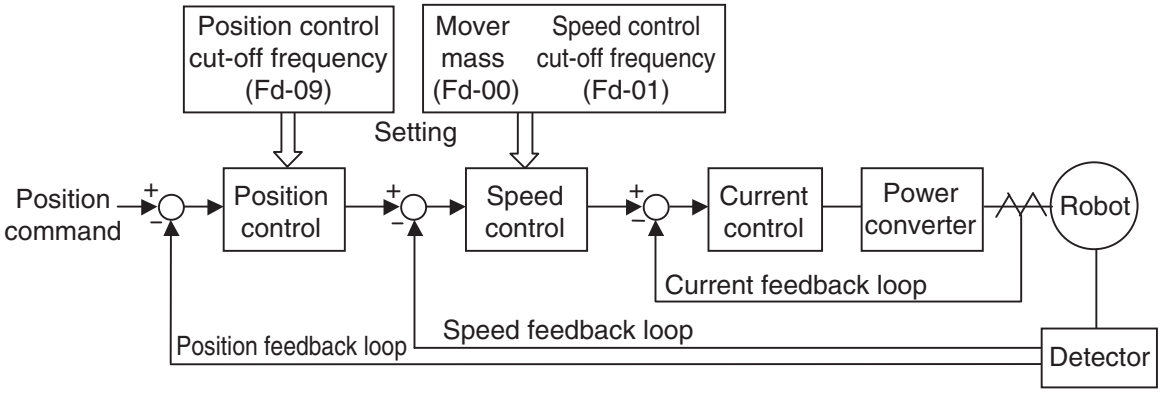
5.9 Adjusting the control gain

This section describes the method for adjusting the control gain required when adjusting the servo system.
Adjusting the control gain is not required when setting the parameters by following the description in 6.3.3, "Reference graph for setting the acceleration and position control cut-off frequency".
If a higher motion response is needed, set the parameters according to the methods for adjusting the control gain explained below.

Main parameter constants you need to adjust are as follows.

- Mover mass (Fd-00)
- Speed control cut-off frequency (Fd-01)
- Position control cut-off frequency (Fd-09)

The block diagram for the servo system is shown below.



5.9.1 Basic rules of gain adjustment

(1) The servo system is made of 3 loops consisting of a position control loop, a speed control loop, and a current control loop. The internal loop process and the response (cut-off frequency) must be set to a high level. You need to adjust the position control loop gain and the speed control loop gain. The current control gain has sufficient response so no adjustment is needed.

(2) The position control loop and the speed control loop require making a setting that yields a balanced response. Basically, set the loop gain in a range that holds the relation: "Position control cut-off frequency" (Fd-09) is lower than "Speed control cut-off frequency" (Fd-01).
As a general guide when making this setting, the "Position control cut-off frequency" (Fd-09) should be less than 1/6th of the "Speed control cut-off frequency" (Fd-01).

(3) The mechanical system might sometimes oscillate if the response of the position control loop is set to a high value. The gain cannot be set any higher than this so use caution. Usually, the response of the position control loop cannot be set higher than the characteristic oscillation frequency of the mechanical system. Set a loop gain that matches the rigidity and strength of the mechanical system. Setting the response and the rigidity of the mechanical system is described next.

5.9.2 Setting the mechanical rigidity and response

Set the response of the servo system according to the rigidity and strength of the machine connected to the robot. Setting the speed/position control cut-off frequency (Fd-09, Fd-01) to a high value shortens the response and settling time to a command, but if set too high, vibration may occur if the rigidity of the mechanical system is low. So set the speed/position control cut-off frequency (Fd-09, Fd-01) to operate within a stable range.
A general guide for setting response according to the rigidity of the mechanical system is given in the following table.
Please note that the values are for a general guide only. Oscillation might occur even in these ranges, so use caution.

Rigidity of mechanical system	Applicable machines	Recommended control cut-off frequency [Hz]	
		Position (Fd-09)	Speed (Fd-01)
Low	Belt-driven or chain-driven machines • Conveyors or carrier machines	1 to 5	6 to 30
Medium	Machines driven by ball screw through gear • General machine tools • Robots	5 to 10	30 to 60
High	Machines directly connected to ball screw • Pick & place machines • Bonding machines	10 or more	60 or more

Specific steps for adjusting the speed/position control loop are described next.

5.9.3 Adjusting the position control loop

(1) Parameter constants used for position control

Parameter constants used for position control are described below.

(a) Position control cut-off frequency (Fd-09)

This parameter constant determines the response of the position control loop. Setting Fd-09 to a high value improves the response and shortens the positioning time.

Note 1:Robot might oscillate if the Fd-09 setting is too large.

(b) Speed control cut-off frequency (Fd-01)

This parameter constant determines the response of the speed control loop. Set it within a range where no mechanical vibration occurs. Setting to a high value improves the response. If the "Mover mass" (Fd-00) of the mechanical system (including robot) was set correctly, then the speed control cut-off frequency is largely equivalent to the value set in Fd-01.

(c) Speed PI control proportional gain (Fd-02)

The speed PI control proportional gain is automatically determined according to the "Speed control cut-off frequency" (Fd-01). However, fine adjustments to the speed PI control proportional gain can be made by setting Fd-02.

(d) Speed PI control integral gain (Fd-03)

The speed PI control integral gain is automatically determined according to the "Speed control cut-off frequency" (Fd-01). However, fine adjustments to the speed PI control integral gain can be made by setting Fd-03.

Note 1:Robot might oscillate if the Fd-03 setting is too large.

(2) Adjustment method

1. Set the "Position control cut-off frequency" (Fd-09) somewhat low, and set the "Speed control cut-off frequency" (Fd-01) in a range where no abnormal noise or oscillation occurs.
2. Set the "Position control cut-off frequency" (Fd-09) to a large value in a range where overshoot and vibrations do not occur. As a general guide, set to 1/6th or less of the "Speed control cut-off frequency" (Fd-01).
3. Lastly, fine-adjust the "Speed PI control proportional gain" (Fd-02) and "Speed PI control integral gain" (Fd-03) while monitoring the settling characteristics and movement, and search for the optimal point.

5.10 Offline auto-tuning function

The auto-tuning function is described here.
Offline auto-tuning is a function for automatically adjusting the servo system gain according to the speed control cutoff frequency.

Offline auto-tuning operates the robot at a pre-determined operating pattern, estimates the mover mass, and correctly sets the "Mover mass" (Fd-00) parameter. The control gain is then automatically set from the "Speed control cut-off frequency" (Fd-01) that determines the response of the speed control loop.

Note 1: It is not necessary to use this function when setting the parameters by following the description in 6.3.3, "Reference graph for setting the acceleration and position control cut-off frequency".

Note 2: To use the auto-tuning function, connect the robot to the equipment, and operate it at the same load as when actually used. The servo system is optimally adjusted for that load.

Note 3: During auto-tuning, the control mode for the speed control loop must be set to "Speed PI control". (Cannot be correctly tuned under IP control.)

Note 4: Moment of inertia may not be estimated correctly, depending on the robot model and operating conditions (load, etc.).

Note 5: During offline auto-tuning, information such as speed settings and torque data can be checked as graphics on the user PC by using the TOP software for RD series. So using the TOP software is recommended.

Note 6: When a PHASER series robot is used, magnetic pole position estimation must be performed before this operation. For information on magnetic pole position estimation,refer to section 5.17, "Magnetic pole position estimation action".

5.10.1 Offline auto-tuning method

(1) Parameter constants used in offline auto-tuning

Parameter constants used at this time are described below.

(a) Auto-tuning mode (FA-10)

This parameter constant permits you to run auto-tuning. To run auto-tuning, set it to "oFL".

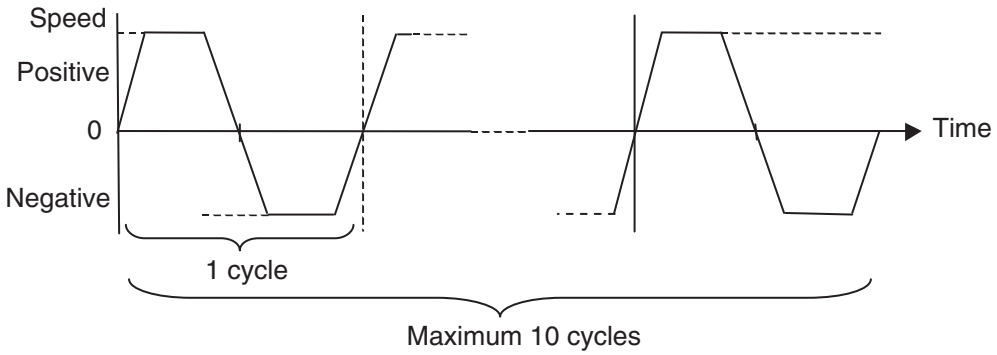
(b) Speed control cut-off frequency (Fd-01)

This parameter constant sets the response of the speed control loop. Set it within a range where oscillation does not occur in the mechanical system. Setting this value higher improves the response.

Note 1: In the case of a large load, the robot might oscillate unless the Fd-01 parameter is set small.

(2)Offline auto-tuning operation

1. Turning on the FOT and ROT terminals, and then turning on the SON terminal starts the auto-tuning. The LED indicator on the robot driver shows "Auto".
2. The robot accelerates and decelerates while moving in both the forward and reverse directions at tuning run speed, centering around the point where auto-tuning started. This movement is 1 cycle and is repeated to a maximum of 10 cycles. (See figure below.) The default setting for the tuning run speed is 1000 [min^{-1}]. This setting can be changed on the TOP software for RD series.
3. Depending on the load condition, the acceleration/deceleration time might be changed or the operation might terminate before 10 cycles are completed.
4. When auto-tuning ends, the estimated mover mass is written into Fd-00. If auto-tuning ends correctly, then the LED indicator on the robot driver shows "End".
5. After auto-turning is complete, turn the RS terminal on and then off, to exit auto-tuning mode.



Operation pattern during off-line auto-tuning

Note 1:This function cannot be used unless the following conditions are met.

- **The acceleration/deceleration torque must be 10% or more of the rated torque.**
- **Machine must have high rigidity including the robot and coupling.**
- **Must have little backlash from gears, etc.**
- **Must be a task where there are no safety problems even if oscillation occurs and there is no damage to equipment.**
- **Auto-tuning can be used with a machine whose mover mass for the load is less than 20 times the robot unit. If the mover mass of the machine is more than 20 times then adjust the gain manually.**
  (See sections 5.9.1 to 5.9.3 in this chapter for information on manual adjustments.)
- **If the tuning speed was set to a low value then set it to a large value within a range that will not damage the machine.**
- **Establish an ample drive range in both the forward and reverse directions. The drive range during turning is shown next.**

Calculating the robot axis rotation during offline auto-tuning

If the tuning speed is Va [min^{-1}] and the accel/decel time is Δt [s], then the robot axis rotation, S, can be calculated by the following formula.

$$S = \frac{3 \cdot Va}{60} \times \Delta t$$

Calculated examples are shown in the following table. Set an ample drive range for the values in the table.
The tuning speed and accel/decel time differ depending on whether operated by the digital operator or using the TOP software as shown next.

Calculated example of robot axis rotation during offline auto-tuning

Tuning speed Va [min^{-1}]	Accel/decel time Δt [s]	Robot axis rotation S [rotation]
500	0.05 0.1	1.25 2.5
1000	0.05 0.1	2.5 5.0
1500	0.05 0.1	3.75 7.5

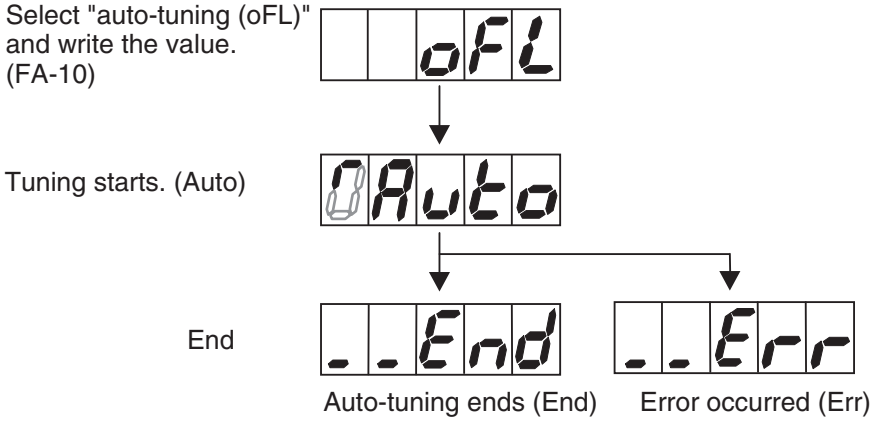
Tuning speed and accel/decel time for off-line auto-tuning

	Tuning speed Va (min^{-1})	Accel/decel time Δt(s)
Digital operator	1000 (fixed)	0.05 (fixed)
TOP software	Adjustable	Adjustable

Note: The accel/decel time during offline auto-tuning is the time required to reach the tuning speed from 0 or slow down to 0 from the tuning speed.

(3) Offline auto-tuning sequence

1. To run offline auto-tuning, select "offline auto-tuning" (oFL) on the "Auto-tuning" (FA-10) parameter, and after writing the value, turn the servo on.



(a) When auto-tuning ends normally:
The estimated momentum of inertia is written in Fd-00.

(b) When an auto-tuning error occurs:
If any of the following events occurred, then a tuning error results.

- An error/abnormality occurred
- The SON terminal turned off during tuning.
- Resonance or similar phenomenon occurred so auto-tuning could not be performed correctly.

2. When tuning ends, turn the SON terminal off, and turn the RS terminal on and then off, to exit the auto-tuning mode.

Note 1: The tuning might not end normally if the accel/decel torque is less than 10 [%] of the rated torque. If that happens, use the TOP software for RD series to set the default value 0.05[s] for the accel/decel time to a smaller value. Also, if a tuning error occurred, then each gain value returns to the value prior to tuning. No alarm will trip unless there is an abnormal condition, so be aware of the need for safety especially during resonance.

Note 2: If you did not turn the RS terminal on and then off in step 2 above after turning ended, then set the "Auto-tuning mode" (FA-10) to "non".

5.10.2 Offline auto-tuning using the TOP software

The TOP (software for RD series) allows you to run fully automatic offline auto-tuning or run one at a time while checking each result. A brief description is given below. For detailed information, refer to the TOP software user's manual.

The following parameter settings are required for auto-tuning.

(a) Cut-off frequency setting

Set the cut-off frequency for controlling the speed during auto-tuning. Set a value that will not cause hunting.

Note 1: In the case of a large load, the robot might cause hunting unless this parameter is set small.

(b) Initial value of tuning mover mass

Set the mover mass at start of auto-tuning. Tuning will end quickly if setting this to a value that you know will roughly match the mover mass. If you do not know this value then leave the setting as is. The auto-tuning function will estimate the mover mass.

(c) Tuning speed

Enter the speed to use for auto-tuning. Enter a speed that will not damage the machine connected to the robot. If the speed is low then the tuning may fail. Set it to a higher speed at a level that will not damage the machine.

(d) Accel/decel time

Set an initial value for accel/decel time for pattern operation during auto-tuning.Set this value to a small value if the accel/decel torque is less than 10% of the rated torque. (Refer to the torque data shown on the display during pattern operation.)

(1)Procedure for fully automatic offline auto-tuning

1. Click the [Test run and Adjustment] button on the opening screen.
   Click the [Offline tuning] tab on the screen that appears.

2. Set the parameters that are required for auto-tuning.

3. Click the [Continuous pattern tuning start] button.

4. Check safety conditions and then turn on the FOT and ROT terminals, and turn on the SON terminal. This starts continuous pattern operation and estimates the mover mass.

5. After estimating the mover mass, the pattern operation waveforms are downloaded from the robot driver and displayed.

6. After tuning ends, turn the SON terminal off, and turn the RS terminal on and then off, to exit the auto-tuning mode.

Note 1:This function automatically rewrites the "Mover mass" (Fd-00) parameter.

Note 2:When tuning is interrupted before it is complete, turn the SON terminal off, and turn the RS terminal on and then off, to exit the auto-tuning mode.

Note 3:If the auto-tuning failed, then see the notes in 5.10.1.

(2)Procedure for offline auto-tuning while checking the result each time

1. Click the [Test run and Adjustment] button on the opening screen.
   Click the [Offline tuning] tab on the screen that appears.

2. Set the parameters that are required for auto-tuning.

3. Click the [1 pattern tuning start] button.

4. Check safety conditions and then turn on the FOT and ROT terminals, and turn on the SON terminal. This starts 1-pattern operation and estimates the mover mass.

5. After estimating the mover mass, the pattern operation waveforms are downloaded from the robot driver and displayed.

6. Check if the waveform is satisfactory and click the [1-pattern tuning start] button again if necessary. This runs the 1-pattern operation and estimates the mover mass. Repeat this to perform tuning while checking one waveform at a time.

7. After tuning ends, turn the SON terminal off, and turn the RS terminal on and then off, to exit the auto-tuning mode.

Note 1:This function automatically rewrites the "Mover mass" (Fd-00) parameter.

Note 2:When tuning is interrupted before it is complete, turn the SON terminal off, and turn the RS terminal on and then off, to exit the auto-tuning mode.

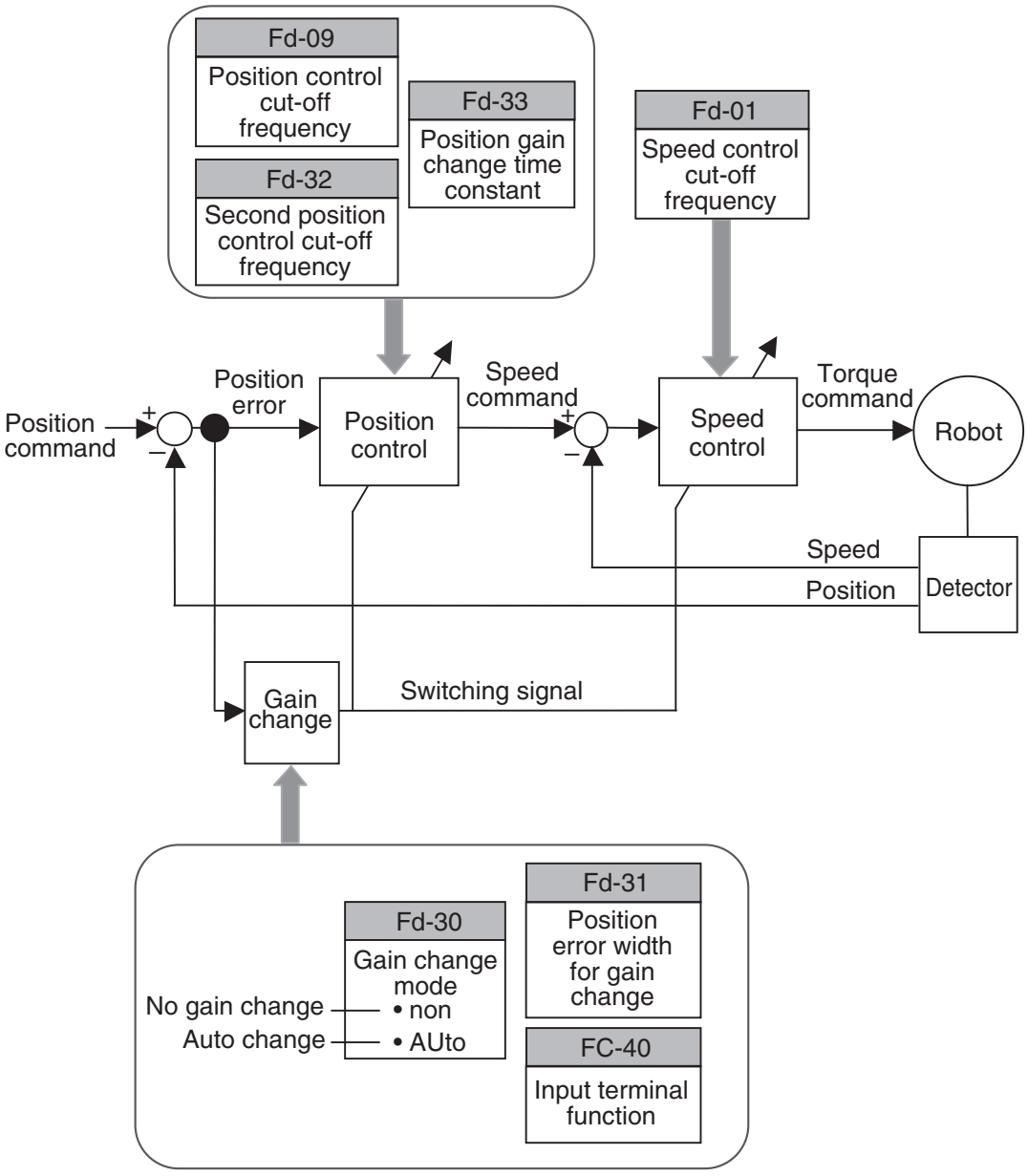
5.11 Gain change function

The gain change function is a function for changing the position and speed control gain during operation and is used in the following cases.

- To raise the control gain during servo-lock but to lower the gain to reduce noise during run.
- To raise the control gain during settling to shorten the settling time.

5.11.1 Changing the control gain

A block diagram of the gain change function is shown below.



(1) Parameter constants used for the gain change function

The parameter constants used for changing the gain are explained below.

(a) Speed control cut-off frequency (Fd-01)

Set the response (cutoff frequency) of the speed control system. This is always enabled.

(b) Position control cut-off frequency (Fd-09)

Set the response (cut-off frequency) of the position control system. This is always enabled.

(c) Gain change mode (Fd-30)

Set whether or not to use the gain change mode.

- **When using "non":**
  The cut-ff frequency of the position control section is equal to the "Position control cut-off frequency" (Fd-09), and the cut-off frequency for the speed control section is equal to the "Speed control cut-off frequency" (Fd-01).
- **When using "AUto":**
  If the position deviation is larger than the "Position error width for gain change" (Fd-31), then the cut-ff frequency of the position control section is equal to the "Position control cut-off frequency" (Fd-09), and the cut-off frequency for the speed control section is equal to the "Speed control cut-off frequency" (Fd-01).
  If the position deviation is smaller than the "Position error width for gain change" (Fd-31), then the cut-ff frequency of the position control section is equal to the "Second position control cut-off frequency" (Fd-32), and the cut-off frequency for the speed control section is equal to the "Second speed control cut-off frequency" (Fd-34).

(d) Position error width for gain change (Fd-31)

Set the "position deviation" where you want to start the gain change.

(e) Second position control cut-off frequency (Fd-32)

Set the position control cut-off frequency to use after gain change.

(f) Position gain change time constant (Fd-33)

Set the filter time constant for gain variations during gain change (Fd-09 ⇔ Fd-32).

(g) Second speed control cut-off frequency (Fd-34)

Set the speed control cut-off frequency to use after gain change.

(h) Speed gain change time constant (Fd-35)

Sets the filter time constant for gain variations during gain change (Fd-01 ⇔ Fd-34).

(2)Procedure for setting the gain change function

1. Set the "Gain change mode" (Fd-30) to "AUto".
   - Set the "Position error width for gain change" (Fd-31).
   - The position control gain is changed based on the interrelation of "Position error monitor" (d-09) and "Position error width for gain change" (Fd-31).

2. Set the "Second position control cut-off frequency" (Fd-32) and the "Second speed control cut-off frequency" (Fd-34).

   Default values are:
   - The default value for the "Second position control cut-off frequency" (Fd-32) is double the value (10.00 [Hz]) of the "Position control cut-off frequency" (Fd-09).
   - The default value for the "Second speed control cut-off frequency" (Fd-34) is double the value (60.00 [Hz]) of the "Speed control cut-off frequency" (Fd-01).
   - As a general guide set the Fd-32 to 1/6th or less of Fd-34.

3. After making the settings in 1 and 2 above, turn the servo on.

Note 1:A large gain difference during the gain change might cause mechanical shocks to the machine. If that happens, set the "Position gain change time constant" (Fd-33) and "Speed gain change time constant" (Fd-35) to a large value (the default value is set to 1 [ms]).

Note 2:If abnormal noise and oscillation occur during servo-lock, then set the "Second position control cut-off frequency" (Fd-32) and the "Second speed control cut-off frequency" (Fd-34) to a value low enough so that abnormal noise and oscillation do not occur.

5.12 Clearing the alarm log and setting the default values

The tripped alarm log can be cleared and all parameter data can be initialized.

Note: Data initialization alone does not reset the robot parameters to their default values. To reset the robot parameters to their default values, generation is required after data initialization. For details on generation, refer to the TOP software user's manual.

The procedure for this resetting is shown below. If the parameter data has deviated from the expected value due, for example, by an entry error, then you can clear the alarm log with the procedure given below or return the parameter to the default value (default value in the robot driver).

(1)When initializing from the digital operator

1. Select initializing mode.
   1-1 Open FA-98, and select one of the following items according to the initializing information.
   Clear Trip Log : CH
   Factory Setting : dAtA
   Clear Position Sensor to Zero : AbS

   1-2 Press the [SET] key.
   (Display changes to FA-98)
   (See Chapter 6, "Parameter description", for information on how to set.)
2. Press the [▽] key for at least 2 seconds while simultaneously holding down the [◁] key.
3. While holding down the above arrow keys, press and release the [SET] key.
   The initializing now starts and the following table appears on the display panel.

Initializing information	LED display
Alarm log clear	HC
Data initializing	JP

   Note: Do not shut down the control power for the robot driver during initialization.
   Shutting off the power while data is being written may destroy the EEPROM data (stored data) within the robot driver, and the robot driver may fail to operate correctly.
4. After the display panel returns to d-00, turn the control power supply off and then back on.

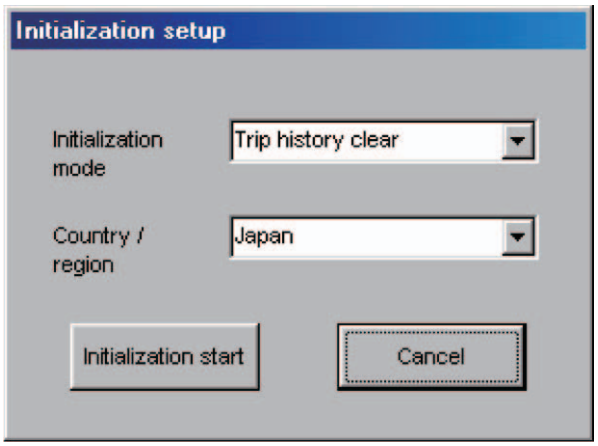
   Note: After initializing the parameters, always perform generation before operating the robot.
   If the robot is operated in the initialized state, it might malfunction or be damaged.

(2)When initializing with the TOP software on the PC

All parameters can be reset to their default values (default values in the robot driver) by using the tool bar or the pull-down menu on the TOP software screen.
Start up the TOP software to make connection with the robot driver.

1. Click on the toolbar on the parameter setup screen.
   (You can also use the pull-down menu.)
2. The "Initialization setup" screen then appears as shown below. In the "Initialization mode" drop-down list select the item you want to initialize.
   The following items can be selected in the "Initialization mode" drop-down list.

   Trip history clear: Clears only the tripped alarm log.
   Data initialization: Clears only the parameter data.



3. Click the [Initialization start] button. Initializing then begins.
   During initializing, the LED indicator on the robot driver shows:
   "HC" → during alarm log clear
   "JP" → during data initialization

Note: Do not shut down the control power for the robot driver during initialization.
Shutting off the power while data is being written may destroy the EEPROM data (stored data) within the robot driver, and the robot driver may fail to operate correctly.

4. After initializing, the data is automatically loaded into the PC from the robot driver, and the initializing then ends.

5. After initializing the parameter data, perform generation.

Note: After initializing the parameters, you must perform generation before operating the robot.
If the robot is operated in the initialized state, it might malfunction or be damaged.

5.13 Motor rotating direction

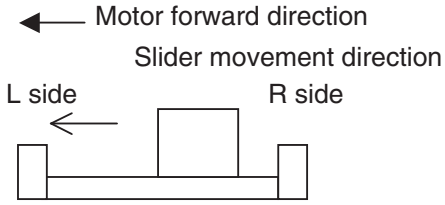
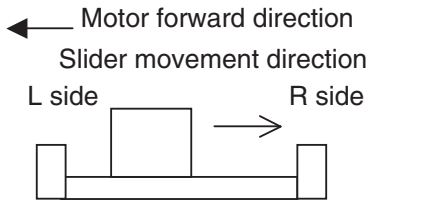
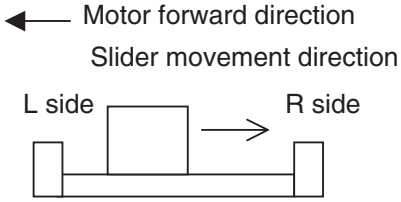
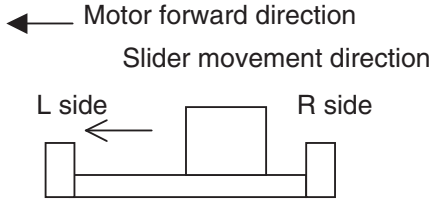
5.13.1 FLIP-X series phase sequence

The forward direction when the RDX is used in combination with the FLIP-X series robot is shown in the table below. The rotating direction for the robot can be set to the reverse direction by changing the "Motor revolution direction" (FA-14) parameter.

Rotation	FA-14	
	CC	C
Forward run	CCW	CW
Reverse run	CW	CCW

5.13.2 PHASER series phase sequence

The forward direction when the RDP is used in combination with the PHASER series robot is shown in the table below. The movement direction for the robot can be set to the reverse direction by changing the "Motor revolution direction" (FA-14) parameter.

Operating direction	FA-14	
	CC	C
Forward run		
Reverse run		

Note1: The above figures are viewed from the cable carrier side of the robot.

5.14 Speed limit function

Speed can be limited by the parameters (Fb-20, Fb-21) as shown in the table below.

Setting	Speed limit mode FA-20	Speed limit value	
		Forward	Reverse
Fixed value by parameter setting	non	Fb-20	Fb-21

5.15 Fast positioning function

The fast positioning function shortens the positioning settling time to the minimum time, and drastically reduces the positioning deviation that occurs during positioning operation.

Note 1: The Moment of inertia (Fd-00) parameter must be set correctly to use this function.

Note 2: When setting this function to improve the tact time, the following parameters also need to be adjusted.

- **Speed control cut-off frequency (Fd-01)**
- **Speed control proportional gain (Fd-02)**
- **Speed control integral gain (Fd-03)**
- **Position control cut-off frequency (Fd-09)**

Note 3: This function may not show its optimal performance depending on the machine conditions.

The parameter constants used with this function are described below.

(a) Fast positioning mode (Fd-40)

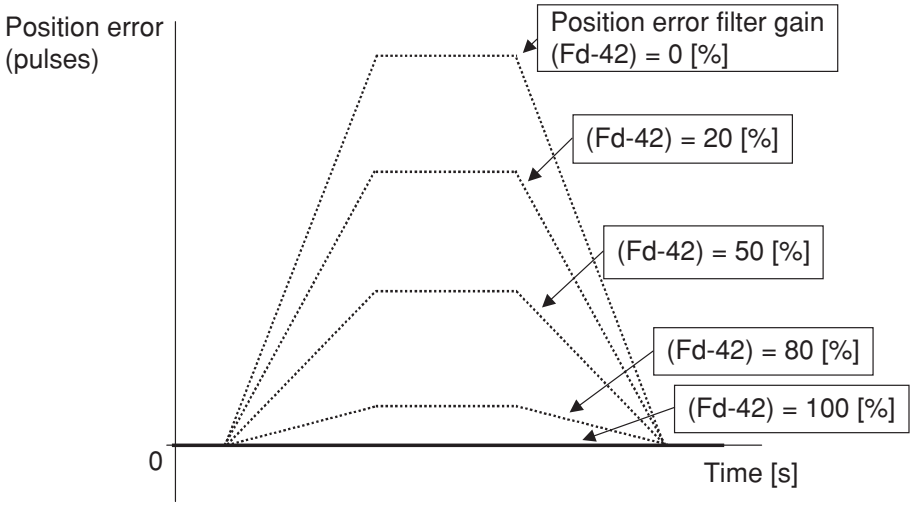
This parameter specifies how to control the fast positioning. To perform positioning in the shortest settling time, set this parameter to "FAst" from "non" or "FoL". To perform positioning while drastically reducing position deviations, use the position deviation minimizing control by setting this parameter to "FoL". The control operation for each setting is described below.

- **Minimizing the positioning settling time "FAst"**

  When the fast positioning mode is set to "FAst" from "non" or "FoL", the control constant parameters are automatically optimized to minimize the positioning settling time. If the fast positioning mode is already set to "FAst", then set it to "non" and then back to "FAst" again. Always be sure to first make the other control parameters (Fd-xx) before setting to "FAst". Making this setting automatically sets the "Position feed forward gain" (Fd-10) and the "Position feed forward filter time constant" (Fd-41).
  Position overshoot might occur depending on the machine being operated. If that happens, adjust the "Position feed forward gain" (Fd-10) that was automatically set, to a new setting where position overshoot does not occur.

- **Minimizing the position deviation "FoL"**

  Setting the fast positioning mode to "FoL" enables the position deviation minimizing control to work. Position deviation or error which may occur can be adjusted by the "Position error filter gain" (Fd-42). (See figure below.)



Effects of position deviation minimizing control (Fd-40 = FoL) during positioning operation

5.16 Notch filter function

The notch filter function reduces the vibration originating from the machine resonance, by lowering the gain at a particular frequency. The parameter constants used in this function are described below. Set these parameters using the TOP software's machine system diagnosis function. See the TOP software user's manual for more information on the machine system diagnosis function.

(a) Notch filter 1 frequency (Fd-12)

This is the first notch filter. Set the frequency where you want to lower the gain.

(b) Notch filter 1 bandwidth (Fd-13)

Set the gain attenuation rate for the notch filter 1. Setting this parameter to 0 disables the notch filter 1.

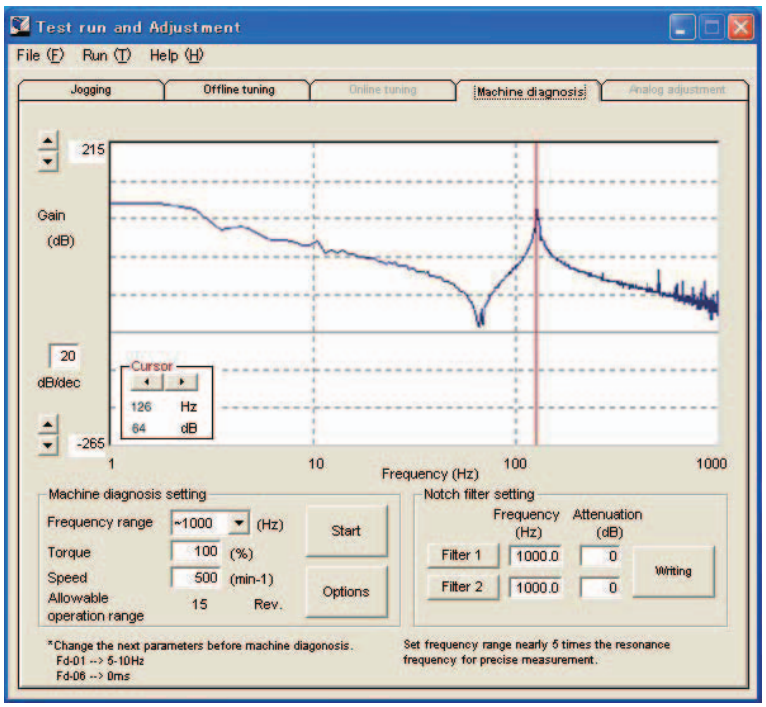
(c) Notch filter 2 frequency (Fd-14)

This is the second notch filter. Set the frequency where you want to lower the gain.

(d) Notch filter 2 bandwidth (Fd-15)

Set the gain attenuation rate for the notch filter 2. Setting this parameter to 0 disables the notch filter 2.

■ Machine system diagnosis function on TOP software

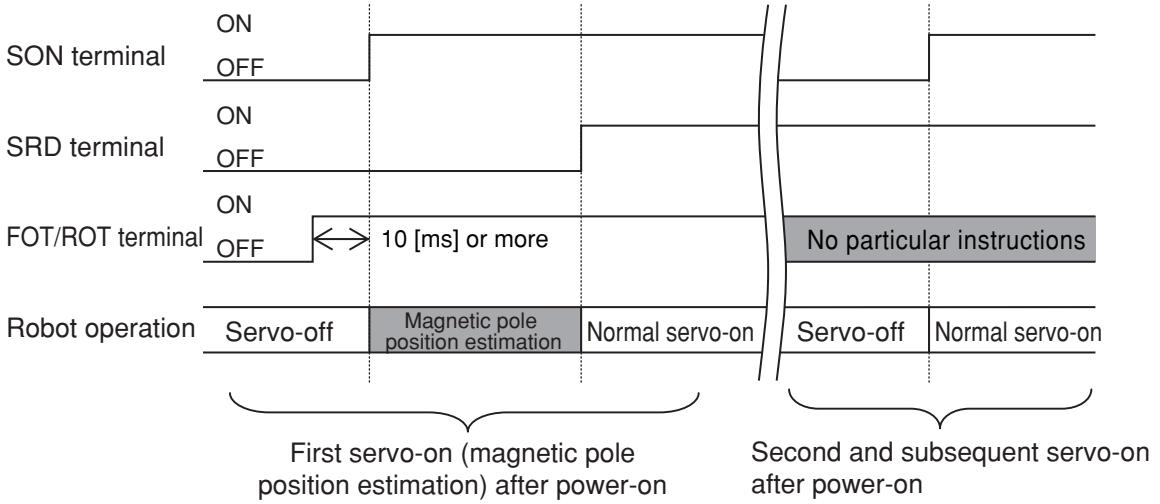


5.17 Magnetic pole position estimation action

On the RDP, magnetic pole position estimation must be performed after power is turned on when operating a robot in pulse train mode. To perform magnetic pole position estimation, set FA90 (Hall sensor connection) to oFF2, and follow the sequence shown below in "Magnetic pole position estimation and terminal states".
The SRD terminal turns "OFF" during magnetic pole estimation, but turns "ON" when the magnetic pole estimation ends correctly. Also, when magnetic pole estimation ended correctly, the normal servo-ON state returns, and the servo operates according to the commands that are input.
To determine the magnetic pole position after magnetic pole position estimation is complete, perform return-to-origin. For detailed information on return-to-origin, see section 5.4, "Return-to-origin function".

Note: To perform magnetic pole position estimation, set FA-90 (Hall sensor connection) to oFF2. Do not set FA-90 to oFF.

■ **Magnetic pole position estimation and terminal states**



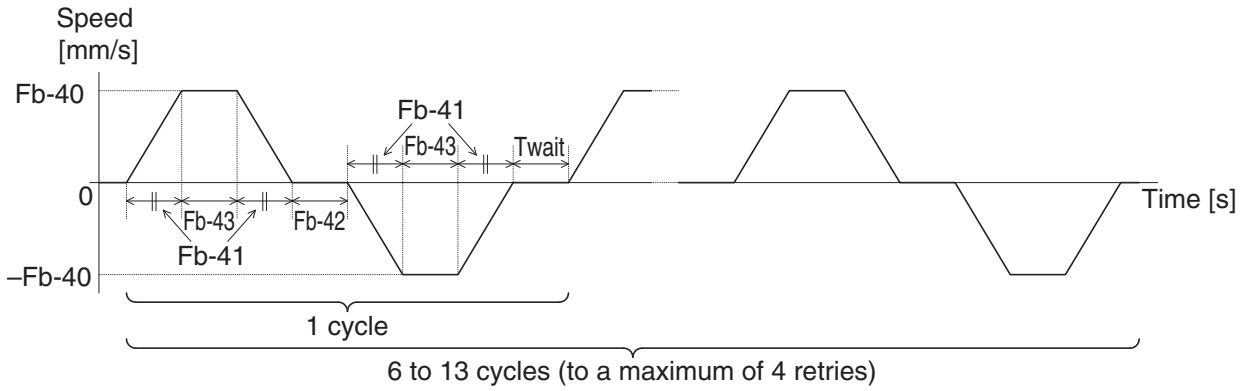
Note 1: The magnetic pole position estimation operation relies on speed command values generated internally in the robot driver so if command values such as position command pulses are input from outside the robot driver, then the robot might suddenly start to operate immediately after the magnetic pole position estimation ends.
So do not enter command values such as position command pulses from outside the robot driver during magnetic pole position estimation.

Note 2: If the magnetic pole position estimation ends in an error, then a magnetic pole position estimation error (E95) occurs.

Note 3: The RDP shipped after October 2008 issues an error E95 (magnetic pole position estimation error) when magnetic pole position estimation starts unless both FOT and ROT terminals are ON. The RDP shipped before then does not issue an error, but fails to estimate the magnetic pole position.

5.18 Magnetic pole position estimation and parameters

The magnetic pole position estimation is performed by repeatedly generating the speed patterns automatically within the robot driver, as shown below. The number of repeating cycles automatically generated in one magnetic pole position estimation ranges from 6 to 13 cycles. (The number of repeating cycles may change according to the robot status.) If failed to estimate the magnetic pole position correctly, a maximum of 4 retries are automatically attempted to estimate the magnetic pole position.



*** Twait (wait time)**

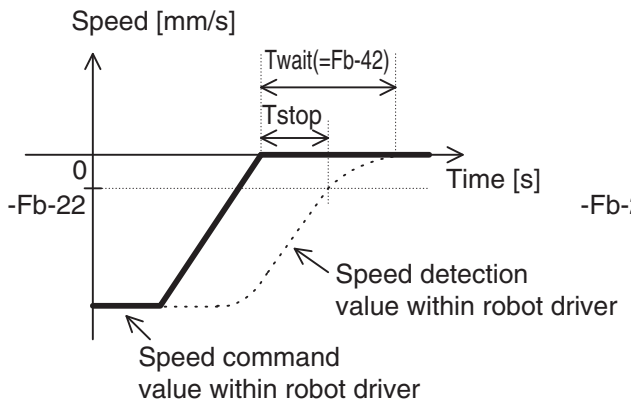
The wait time Twait [s] for 1 operation pattern cycle is shown in the formula below. The wait time Twait [s] under two conditions: (1) Fb-42 [s] ≥ Tstop [s], and (2) Fb-42 [s] < Tstop [s], are shown below.

$$\text{Twait [s]} \begin{cases} = \text{Fb-42 [s]} & \text{(1) Fb-42 [s]} \geq \text{Tstop [s]} \\ = \text{Tstop [s]} & \text{(2) Fb-42 [s]} < \text{Tstop [s]} \end{cases}$$

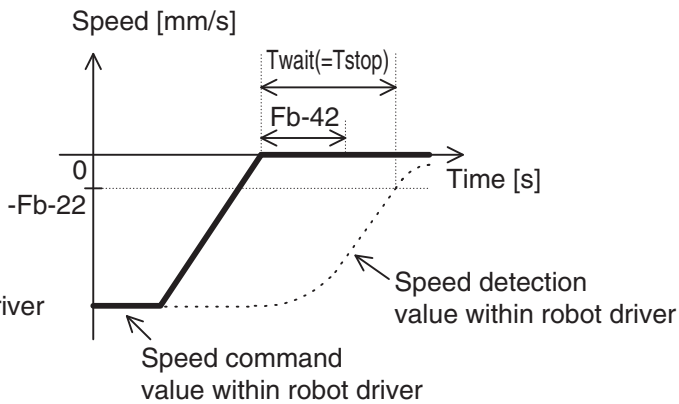
Tstop [s]: This is the time in seconds for the speed detection value of 0 [mm/s] in the robot driver, to converge to the range of the "Zero speed detection value" (Fb-22) .

<Wait time Twait state (relation between speed command value, speed detection value within robot driver and wait time Twait [s]>

(1) Fb-42[s] ≥ Tstop[s] (Twait = Fb-24)



(2) Fb-42[s] < Tstop[s] (Twait = Tstop)



The distance the motor or slider moves during magnetic pole position estimation can be derived by the following formula.

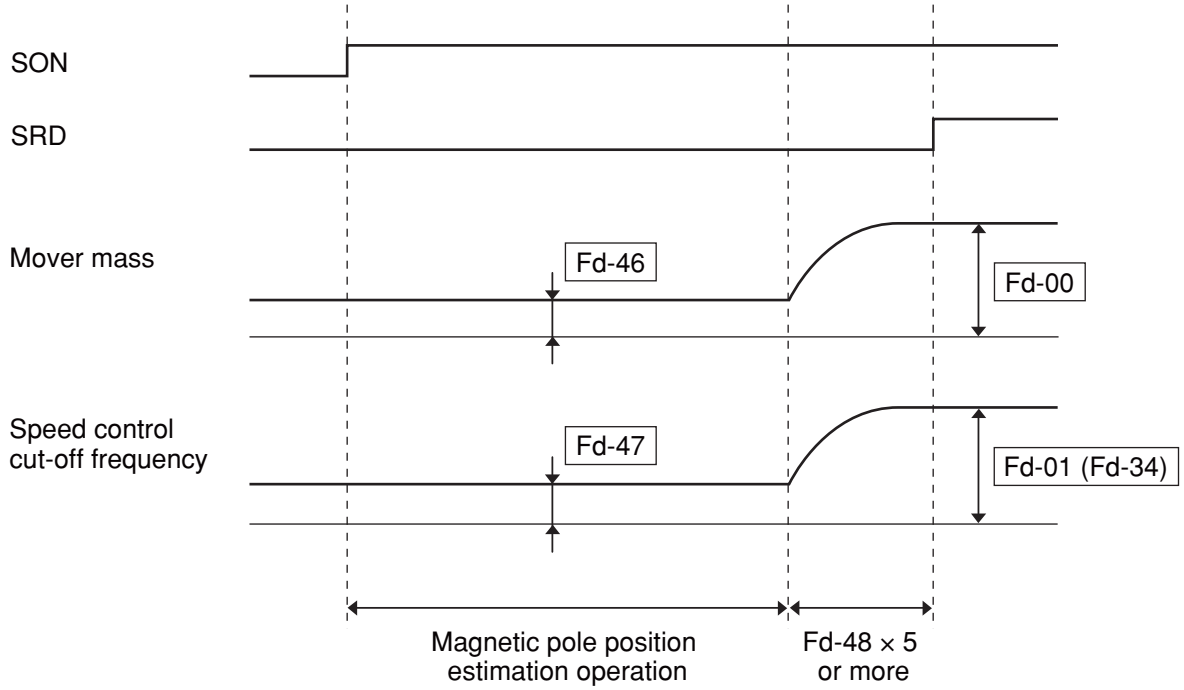
Movement distance [mm] = Fb-40 ×(Fb-41 + Fb-43) / 1000

Example: Distance moved with Fb-40=80, Fb-41=10, and Fb-43=10

Movement distance [mm] = 80 ×(10 + 10) / 1000 = 1.6 [mm]

[Mover mass and speed control cut-off frequency for magnetic pole position estimation]

Use Fd-46 (Mover mass for pole position estimation) to set the mover mass for magnetic pole position estimation. Likewise, use Fd-47 (Speed control cut-off frequency for pole position estimation) to set the speed control cut-off frequency. Also use Fd-48 (Gain change time constant after pole position estimation) to set the time constant of the first-order lag filter for gain switching when shifting to normal control after estimating the magnetic pole position.



Note 1: Fd-46, Fd-47 and Fd-48 cannot be set for RDP that was shipped initially. Use Fd-00 and Fd-01 to set the mover mass and speed control cut-off frequency for magnetic pole position estimation and normal control operation.

Note 2: These parameters can be set with the dedicated software TOP (Ver. 6.5.1 or later). If using an earlier version of TOP, set them from the front panel.

<To shorten the distance moved during magnetic pole position estimation>

Setting the parameters as shown below in (1) through (3) shortens the distance moved during magnetic pole position estimation.

(1) Set Fb-42 (Pole position estimation wait time) to approximately 300 [ms].

(2) Set as follows to reduce the movement distance.

- Fb-41 (Pole position estimation ACC/DEC time) = 10 [ms]
- Fb-43 (Pole position estimation constant-speed time) = 0 [ms]

(3) To decrease the movement distance, adjust Fb-40 (Pole position estimation speed) to a small value.

Note 1: Magnetic pole position estimation might sometimes be unable to accurately estimate the magnetic pole position due to how the torque is generated during the magnetic pole position estimation period.

Note 2: If an abnormal movement occurs, adjust the Fd-46, Fd-47 and/or Fd-48 parameters.

Note 3: Depending on the robot load conditions, magnetic pole position estimation may fail with an error E95 (magnetic pole position estimation error). If this happens, adjust the pole position estimation parameter to an appropriate value.

Note 4: The center position of the magnetic pole position estimation operation may shift, depending on the start position.

Note 5: After magnetic pole position estimation is complete, the magnetic pole position is determined when phase ZM is passed.

Chapter 6 Parameter description

This chapter describes part names of the digital operator integrated into this product and how to operate it. This chapter also describes monitor mode and setup parameters.

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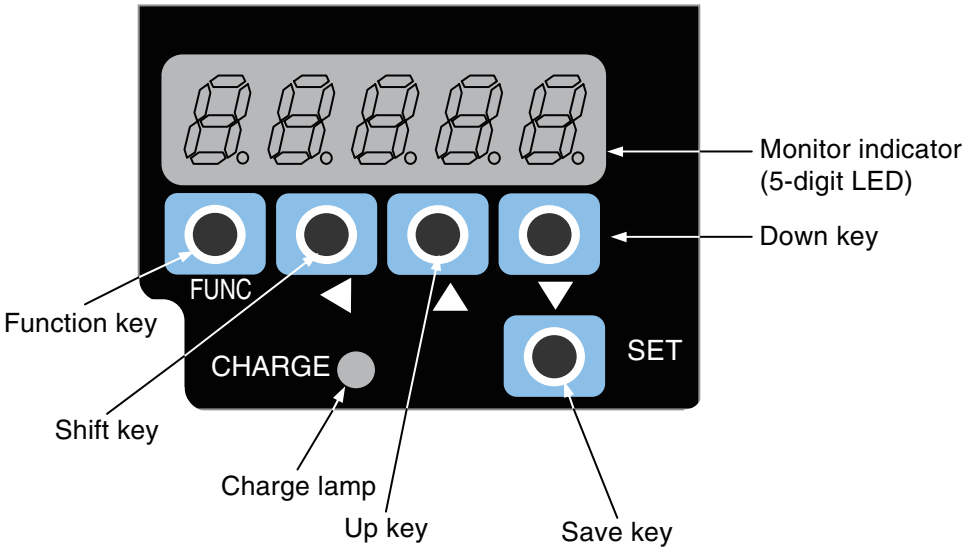
6.1 Digital operator part names and operation

6.1.1 Part names of digital operator

The RD series is operated from the built-in digital operator.

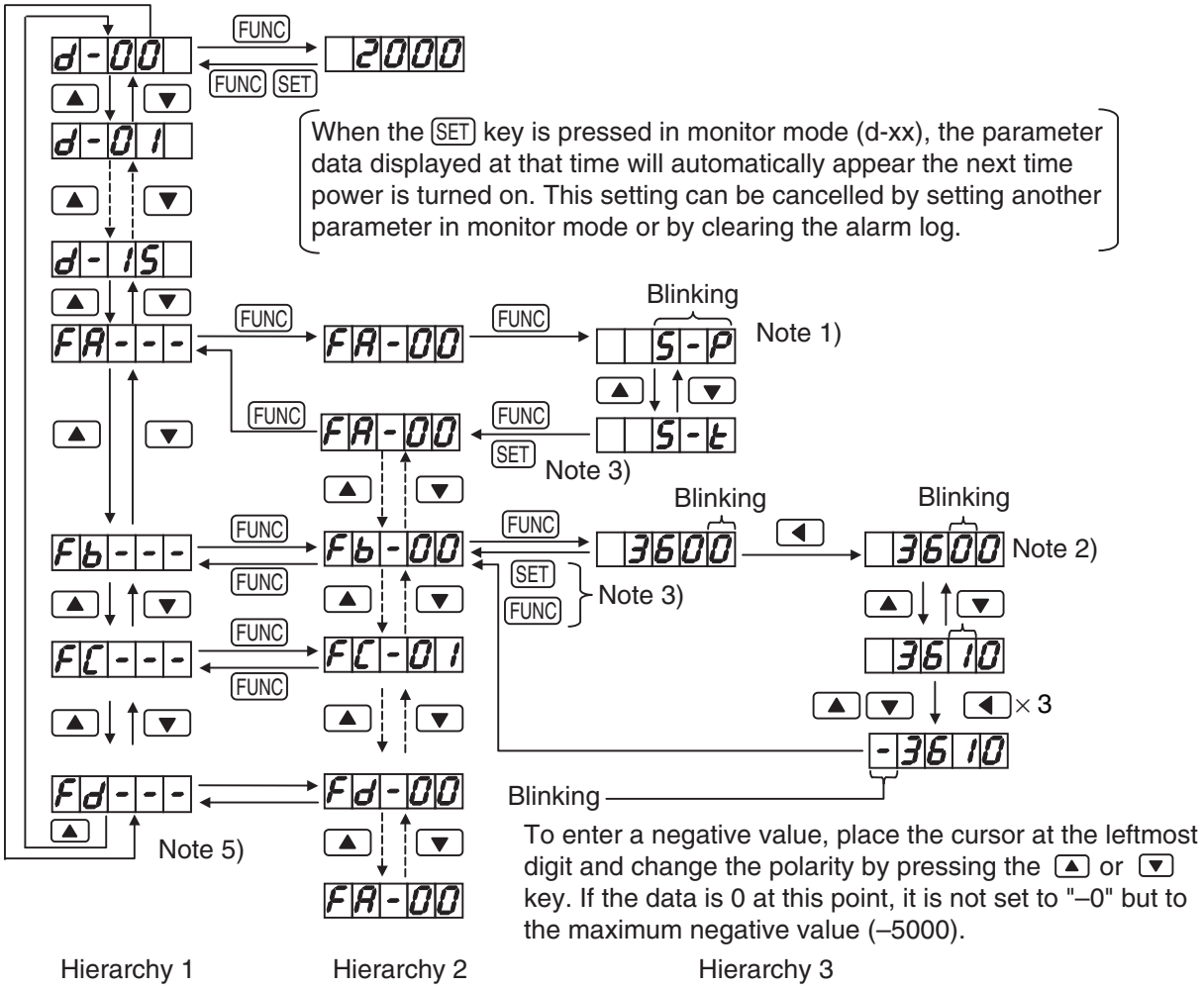


Name	Description
Monitor indicator	Displays a monitor value or set value.
Charge lamp	Lights up when charge in DC bus capacitor exceeds 30V.
FUNC **Function key**	Enters the monitor mode or parameter setting mode.
Shift key	Moves the indicating digit or setting digit to the left. Pressing this key at the leftmost digit moves the selected position to the rightmost digit.
Up key **Down key**	Changes the monitor number, setup parameter number, or parameter setting.
SET **Save key**	Saves parameter setting.

6.1.2 Operating the digital operator

(1)Changing the monitor mode display and parameter setting

The button marks over/under the right/left arrows (⇄) or at the side of the up/down arrows (↓↑) show that those buttons were pressed. To save data you have entered always be sure to press the SET key. Pressing the FUNC key will not save the data but retains the previous value.


d-00
2000
d-01
d-15
FA---
FA-00
Blinking
S-P
Note 1)
S-t
Note 3)
Fb---
Fb-00
3600
Note 2)
3610
× 3
-3610
FC---
FC-01
Fd---
Fd-00
Note 5)
When the SET key is pressed in monitor mode (d-xx), the parameter data displayed at that time will automatically appear the next time power is turned on. This setting can be cancelled by setting another parameter in monitor mode or by clearing the alarm log.
To enter a negative value, place the cursor at the leftmost digit and change the polarity by pressing the ▲ or ▼ key. If the data is 0 at this point, it is not set to "–0" but to the maximum negative value (–5000).
Hierarchy 1
Hierarchy 2
Hierarchy 3

Note 1: When the FUNC key in hierarchy 1 is held down, the hierarchy changes in order, from hierarchy 2 → hierarchy 3 → hierarchy 2 → hierarchy 1. The parameter name displayed after pressing the FUNC key at FA--- (hierarchy 1) will be the parameter name that was last displayed at hierarchy 3 (if up to hierarchy 3 was displayed).

Note 2: The blinking digit indicates the current cursor position.

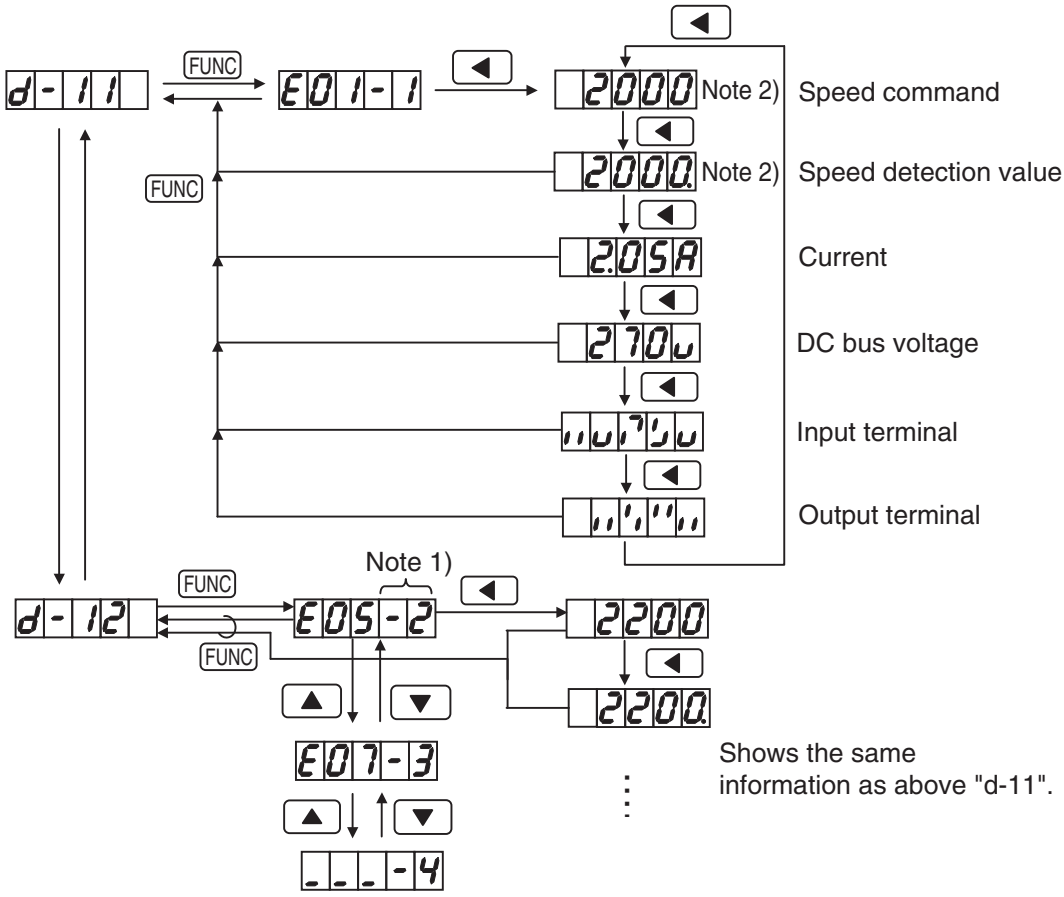
Note 3: Pressing the SET key saves the data you have entered.
Pressing the FUNC key cancels the data you have entered and retains the previous value.

Note 4: When changing a parameter (FA-12, FA-13, etc.) from "100" to "001", the minimum setting range prevents changing it from the higher-order digit to "000". So, first set it to "101" and then change it to "001".

Note 5: To quickly move from the monitor mode display (d-xx) to the parameter setting mode (FA to Fd) use the ▲ or ▼ keys.

(2)Operating the trip monitor and the trip log monitor

The button marks over/under the right/left arrows (⇄) or at the side of the up/down arrows (↓↑) show that those buttons were pressed.



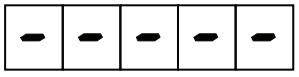
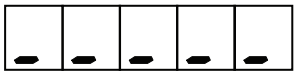
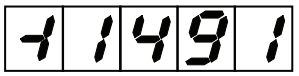
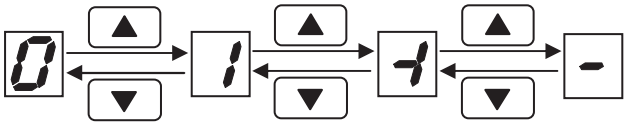
Note 1: The number at the right of the alarm code shows the alarm log number. The number "1" is the newest data. The larger the log number the older the log. For more information refer to 9.1, "Alarm display (alarm log)".

Note 2: A period (.) in the last digit indicates the following information.

Period	Displayed information	Remarks
No	Speed command	Two speed data items (speed command and speed detection value) are used and can be identified by the period on the trip monitor.
Yes	Speed detection value	

(3) Special display

A special display appears to indicate the robot driver status as shown in the following table.

Display	Description
	Voltage is too low during servo-off. (Control power supply)
	No alarm log is stored.
	User initialization in-progress. (LED segments within the leftmost digit light in sequence.)
	Log initialization in-progress. (LED segments within the leftmost digit light in sequence.
	Sample display: When setting Fb-14, Fb-16 or Fb-18 to a value between –10000 and –19999. Display at left shows a parameter value of –11491. (A minus sign "-" is appended to the leftmost digit "1" in order to indicate a 6-digit number including a sign.) <To set Fb-14, Fb-16 and Fb-18:> As the basic method, use the ◀ key to select the digit you want to change and then use the ▲ or ▼ key to set the desired value. Note that the leftmost digit is displayed as follows:  Press the SET key when the desired value is displayed.

6.2 Function lists

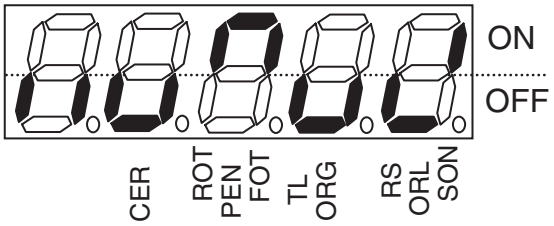
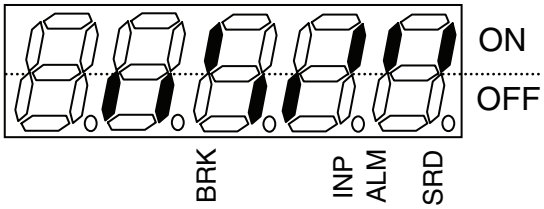
This section describes monitor functions and parameters that can be set for the robot driver. Parameters are divided into several groups as shown in the following table.

Group	Description
d-xx	Allows checking monitor parameters such as speed and position.
FA-xx	Operation mode or protection level parameters
Fb-xx	Operation constant parameters
FC-xx	Input/output terminal parameters
Fd-xx	Control constant parameters such as mover mass and response speed.

"xx" means a parameter number.

Parameters for each group are listed on the following pages.

6.2.1 List of monitor functions

Parameter No.	Parameter name	Display range	Units	
			RDX	RDP
d-00	Speed command monitor	-7000 to 7000	min^{-1}	mm/s
d-01	Speed detection value monitor	-7000 to 7000	min^{-1}	mm/s
d-02	Output current monitor	0 to 400	%	
d-03	Torque command monitor	-400 to 400	%	
d-04	Output torque monitor	-400 to 400	%	
d-05	Input terminal monitor			
d-06	Output terminal monitor			
d-07	Position command monitor	80000000 (negative maximum) to 7FFFFFFF (positive maximum)	pulses	
d-08	Present position monitor	80000000 (negative maximum) to 7FFFFFFF (positive maximum)	pulses	
d-09	Position error monitor	80000000 (negative maximum) to 7FFFFFFF (positive maximum)	pulses	
d-10	Output voltage monitor	0 to 400	V	
d-11	Trip monitor	Displays the speed command value, speed detection value, current value, DC bus voltage, input terminal information, and output terminal information when a trip (alarm) occurs.	–	
d-12	Trip log monitor	Displays the past 3 alarm logs except the latest log, which are stored in memory. Displays the speed command value, speed detection value, current value, DC bus voltage, input terminal information, and output terminal information when an alarm has tripped.	–	
d-13	Operation control mode monitor	trq / SPd / PoS	–	
d-14	Operation status monitor	non / run / trP / Fot / rot / ot	–	
d-15	Detected moment-of-inertia monitor	"Motor rotor inertia" to "motor rotor inertia × 128"	$\times 10^{-4} kg \cdot m^2$	×10kg
d-16	Phase Z position monitor (Magnetic pole position counter monitor)	0 to 8192 (Maximum value is equal to FC-09.)	pulses	
d-17	Do not use.	Do not use.	–	
d-18	Machine reference	0 to 100	%	
d-32	Regenerative braking operating ratio monitor	0 to 100	%	

6.2.2 List of setup parameters

Parameter setting ranges and default values are shown in the following tables.

(1)Operation mode parameters

Parameter No.	Parameter name	Setting range	Default setting		Units		Change during operation
			RDX	RDP	RDX	RDP	
FA-00 (Note 3)	Control mode	S-P, S-t, P-t, P-S, t-S, t-P	P-S		–		No
FA-01	Position sensor wire breaking detection	OFF, on	on		–		No
FA-02	Allowable time of power failure	0.00, 0.05 to 1.00	0.00		s		No
FA-03	Overspeed error detection level	0 to 150	110		%		No
FA-04	Speed error detection value	0 to maximum speed	Depends on model		min^{-1}	mm/s	No
FA-05	Position error detection value	0.0 to 100.0	20.0		rotation		No
FA-07 (Note 3)	DC bus power supply	L123, Pn	L123		–		No
FA-08	Regenerative braking operating ratio	0.0 to 100.0	Depends on model		%		No
FA-09	Overload notice level	20 to 100	80		%		No
FA-10	Auto tuning mode	non, oFL, FFt onL1, onL2 (Note 3)	non		–		No
FA-11	Pulse train input mode	F-r, P-S, A-b r-F, -P-S, b-A	F-r		–		No
FA-12	Electronic gear numerator	1 to 65535	Depends on model	1	–		No
FA-13	Electronic gear denominator	1 to 65535			–		No
FA-14	Motor revolution direction	CC, C	Depends on model		–		No
FA-16	DB Operation selection	non, trP, SoF	SoF		–		No
FA-17 (Note 3)	Torque limit mode	non, A2, oP	non		–		No
FA-18	Torque bias mode	non, CnS A2, oP (Note 3)	non		–		No
FA-20 (Note 3)	Speed limit mode	non, A1, oP	non		–		No
FA-22 (Note 3)	Position command selection	PLS, Pro, oP	PLS		–		No

Note 1: Displayed on RDP only.

Note 2: Invalid on RDP.

Note 3: Do not change the setting.

Note 4: Set this parameter to the default value for each model.

Parameter No.	Parameter name	Setting range	Default setting		Units		Change during operation
			RDX	RDP	RDX	RDP	
FA-23	Homing mode	L-F, L-r, H1-F, H1-r, H2-F, H2-r, CP (Note 3) t-F, t-r, S-F, S-r	Depends on model		–		–
FA-24	Servo OFF wait time	0.00 to 1.00	0.05		s		No
FA-25	Operation range at machine diagnosis	1 to 255	10		rotation		No
FA-26 (Note 2)	Brake operation start speed	0 to maximum speed	30		min^{-1}	mm/s	No
FA-27 (Note 2)	Brake operation start time	0, 0.004 to 1.000	0.000		s		No
FA-28 (Note 4)	Electronic thermal level	20 to 105	Depends on model		%		No
FA-80 (Note 3)	Position sensor type selection	inC, AbS	inC		–		No
FA-81 (Note 3)	Position sensor selection	Stnd, inCE, AbSE1, AbSE2, AbSA2, AbSA4	inCE		–		No
FA-82 (Note 4)	Position sensor resolution	500 to 65535 (FA-81=inCE)	4096	Depends on model	pulses		No
FA-85 (Note 1), (Note 3)	Linear scale accuracy	0.01 to 655.35	1.00		μm		No
FA-86 (Note 1)	Pole position offset	8000 to 7FFF	0		–		No
FA-87 (Note 1), (Note 3)	Linear scale polarity	A, b	b		–		No
FA-88 (Note 1), (Note 3)	Phase angle of pole position	PHASE, LinE	PHASE		–		No
FA-89 (Note 1), (Note 3)	Preset condition for pole position	OrLP, OrLn	OrLP		–		No
FA-90 (Note 1)	Hall sensor connection	oFF2 oFF, CnCt (Note 3)	oFF2		–		No
FA-98	Initialization mode selection	CH, dAtA AbS (Note 3)	CH		–		No

Note 1: Displayed on RDP only.

Note 2: Invalid on RDP.

Note 3: Do not change the setting.

Note 4: Set this parameter to the default value for each model.

(2)Operation constant parameters

Parameter No.	Parameter name	Setting range		Default setting		Units		Change during operation
		RDX	RDP	RDX	RDP	RDX	RDP	
Fb-04	Acceleration time	0.00 to 99.99		10.00		s		Yes
Fb-05	Deceleration time	0.00 to 99.99		10.00		s		Yes
Fb-07	Torque limit value 1 (first quadrant)	0 to maximum torque		Depends on model		%		Yes
Fb-08	Torque limit value 2 (second quadrant)	0 to maximum torque		Depends on model		%		Yes
Fb-09	Torque limit value 3 (third quadrant)	0 to maximum torque		Depends on model		%		Yes
Fb-10	Torque limit value 4 (fourth quadrant)	0 to maximum torque		Depends on model		%		Yes
Fb-11	Torque bias value	±0 to ±300		0		%		Yes
Fb-12	Homing speed 1 (fast)	1 to maximum speed	1 to 100	60	20	min^{-1}	mm/s	Yes
Fb-13	Homing speed 2 (slow)	1 to 999	1 to 20	6	5	min^{-1}	mm/s	Yes
Fb-14	Homing position offset value (H)	±0 to ±19999		0		pulses		Yes
Fb-15	Homing position offset value (L)	0 to 99999		0		pulses		Yes
Fb-16	Forward position limit value (H)	±0 to ±19999		0		pulses		Yes
Fb-17	Forward position limit value (L)	0 to 99999		0		pulses		Yes
Fb-18	Reverse position limit value (H)	±0 to ±19999		0		pulses		Yes
Fb-19	Reverse position limit value (L)	0 to 99999		0		pulses		Yes
Fb-20	Forward speed limit value	0 to maximum speed		Depends on model		min^{-1}	mm/s	Yes
Fb-21	Reverse speed limit value	– maximum speed to 0		Depends on model		min^{-1}	mm/s	Yes
Fb-23	Positioning defection range	1 to 65535		20		pulses		Yes
Fb-24	Positioning interval time limit	0.00 to 10.00 (in 0.02 steps)		0.00		s		Yes
Fb-25	Up to speed detection range	0 to 100		10		min^{-1}	mm/s	Yes
Fb-30 (Note 2)	S-curve ratio	non, SHArP, rEGLr, LooSE		non		–		Yes
Fb-35	Homing back distance	1 to 255		Depends on model		–		No
Fb-36	Current for striking limit	40 to 100		Depends on model		%		No
Fb-37	Time for striking limit	0.1 to 2.0		0.2		s		No
Fb-40 (Note 1)	Pole position estimation speed	–500 to 500		Depends on model		mm/s		Yes
Fb-41 (Note 1)	Pole position estimation ACC/ DEC time	10 to 500		Depends on model		ms		Yes
Fb-42 (Note 1)	Pole position estimation wait time	0 to 500		100		ms		Yes
Fb-43 (Note 1)	Pole position estimation constant-speed time	0 to 500		Depends on model		ms		Yes
Fb-44 (Note 1)	Position sensor wire breaking detection current	20 to 100		Depends on model		%		Yes
Fb-45 (Note 1)	Speed error detection value at pole position estimation	0 to maximum speed		500		mm/s		No

Note 1: Displayed on RDP only.

Note 2: Do not change the setting.

(3)Input/output terminal parameters

Parameter No.	Parameter name	Setting range	Default setting		Units		Change during operation
			RDX	RDP	RDX	RDP	
FC-01	Input terminal polarity setting	0000 to 3FFF	0400		–		No
FC-02	Output terminal polarity setting	0000 to 00FF	0002		–		No
FC-09	Position sensor monitor resolution M	16 to 8192	1		–		No
FC-10	Position sensor monitor resolution N	1 to 8192	4	1	–		No
FC-11 (Note 1)	Position sensor monitor polarity	A, b	b		–		No
FC-12 (Note 1)	Phase Z output selection	1PLS, nCunt ECunt, qFort	1PLS		–		No
FC-19	Command pulse filter time constant	Lo, Hi	Hi		–		No
FC-21	Communication baud rate	1200, 2400, 4800, 9600, 19200, 38400	19200		bps		No
FC-22	Communication bit length	7, 8	8		bit		No
FC-23	Communication parity	non, odd, EvEn	non		–		No
FC-24	Communication stop bit	1, 2	2		–		No
FC-30	Monitor output 1 function	nrF, nFb, iFb, tqr, nEr, PEr, PFq, brd	nFb		–		No
FC-31	Monitor output 1 polarity	SiGn, AbS	SiGn		–		No
FC-32	Monitor output 1 gain	0.0 to 3000.0	100.0		%		No
FC-33	Monitor output 2 function	nrF, nFb, iFb, tqr, nEr, PEr, PFq, brd	tqr		–		No
FC-34	Monitor output 2 polarity	SiGn, AbS	SiGn		–		No
FC-35	Monitor output 2 gain	0.0 to 3000.0	100.0		%		No
FC-40	Input terminal function	0 to 3FFF	0		–		No
FC-70 (Note 1)	Debug mode selection	0	0		–		–

Note 1: Do not change the setting.

(4)Control constant parameters

Parameter No.	Parameter name	Setting range	Default setting	Units		Change during operation
				RDX	RDP	
Fd-00	Moment of inertia (RDX) Mover mass (RDP)	"Motor rotor inertia" to "motor rotor inertia x 128"	Depends on model	$\times 10^{-4}$kg·m^2	×10kg	Yes
Fd-01	Speed control cut-off frequency	0.1 to 500.0	Depends on model	Hz		Yes
Fd-02	Speed control proportional gain	0.01 to 300.00	Depends on model	%		Yes
Fd-03	Speed control integral gain	0.01 to 300.00	Depends on model	%		Yes
Fd-04	P-control gain	0.1 to 99.9	Depends on model	%		Yes
Fd-05	IP-control gain	0.00 to 1.00	Depends on model	–		Yes
Fd-06	Torque command filter time constant	0.00 to 500.00	Depends on model	ms		Yes
Fd-07	Position phase compensating ratio	0.01 to 9.99	Depends on model	–		Yes
Fd-08	Position phase compensating time constant	0.1 to 999.9	Depends on model	ms		Yes
Fd-09	Position control cut-off frequency	0.01 to 99.99	Depends on model	Hz		Yes
Fd-10	Position feed forward gain	0.00 to 1.00	Depends on model	–		Yes
Fd-12	Notch filter 1 frequency	3.0 to 1000.0	Depends on model	Hz		Yes
Fd-13	Notch filter 1 bandwidth	0 to 40	Depends on model	dB		Yes
Fd-14	Notch filter 2 frequency	3.0 to 1000.0	Depends on model	Hz		Yes
Fd-15	Notch filter 2 bandwidth	0 to 40	Depends on model	dB		Yes
Fd-20	Speed command filter time constant	0 to 60000	Depends on model	ms		Yes
Fd-30	Gain change mode	non, AUto GCH (Note 2)	Depends on model	–		Yes
Fd-31	Position error width for gain change	0 to 65535	Depends on model	pulses		Yes
Fd-32	Second position control cut-off frequency	0.01 to 99.99	Depends on model	Hz		Yes
Fd-33	Position gain change time constant	0.0 to 500.0	Depends on model	ms		Yes
Fd-36	Position command filter time constant	0 to 60000	Depends on model	ms		Yes
Fd-40	Fast positioning mode	non, FASt, FoL	Depends on model	–		Yes
Fd-41	Position feed forward filter time constant	0.00 to 500.00	Depends on model	ms		Yes
Fd-42	Position error filter gain	0 to 100	Depends on model	%		Yes
Fd-44 (Note 1)	Speed feedback filter time constant	0.00 to 500.00	Depends on model	ms		No
Fd-46 (Note 1)	Mover mass for pole position estimation	"Robot mass" to "robot mass x 128"	Depends on model	×10kg		No
Fd-47 (Note 1)	Speed control cut-off frequency for pole position estimation	0.1 to 500.0	Depends on model	Hz		No
Fd-48 (Note 1)	Gain change time constant after pole position estimation	0.0 to 500.0	Depends on model	ms		No

Note 1: Displayed on RDP only.
Note 2: Do not change the setting.

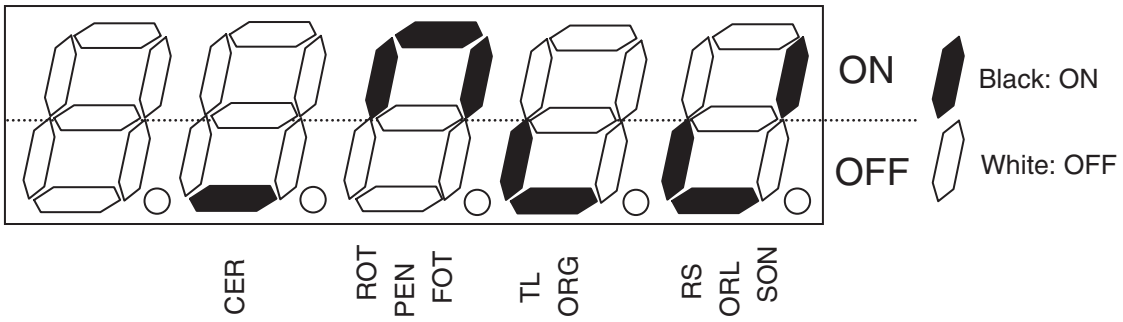
6.3 Function description

6.3.1 Monitor display description

To automatically display a parameter setting when power is on, display the monitor for that parameter and press the SET key. This allows setting that parameter to appear when power is turned on next time. This setting is cancelled when you clear the alarm log.

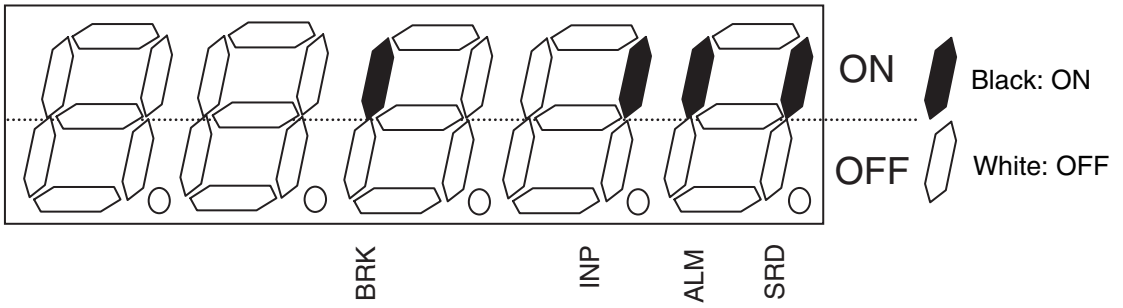
Monitor No.	Monitor name	Display range	Description
d-00	Speed command monitor	–7000 to 7000 RDX [min^{-1}] RDP [mm/s]	Displays the signed speed command value in 1 min^{-1} units.
d-01	Speed detection value monitor	–7000 to 7000 RDX [min^{-1}] RDP [mm/s]	Displays the signed speed detection value in 1 min^{-1} units.
d-02	Output current monitor	0 to 400 [%]	Displays the output current in 1% units.
d-03	Torque command monitor	–400 to 400 [%]	Displays the torque command in 1% units.
d-04	Output torque monitor	–400 to 400 [%]	Displays the output torque in 1% units.
d-05	Input terminal monitor	Displays the input terminal status. (See below.)	

In this example, SON, FOT, ROT and PEN are ON and the others are OFF.



d-06	Output terminal monitor	Displays the output terminal status. (See below.)

In this example, OL1 and TLM are OFF, and the others are ON.



Monitor No.	Monitor name	Display range	Description
d-07	Position command monitor	80000000 (negative maximum) to 7FFFFFFF (positive maximum) [pulses]	Displays the position command in a hexadecimal 32-bit signed (two's complement) value. Displays the 5 low-order digits immediately after d-07 is opened. The display shifts to high-order digits by pressing ◁ to allow checking high-order digits. (A decimal point is placed between high-order word and low-order word.)
d-08	Present position monitor	80000000 (negative maximum) to 7FFFFFFF (positive maximum) [pulses]	Displays the position command in a hexadecimal 32-bit signed (two's complement) value. Displays the 5 low-order digits immediately after d-08 is opened. The display shifts to high-order digits by pressing ◁ to allow checking high-order digits. (A decimal point is placed between high-order word and low-order word.)
d-09	Position error monitor	80000000 (negative maximum) to 7FFFFFFF (positive maximum) [pulses]	Displays the position command in a hexadecimal 32-bit signed (two's complement) value. Displays the 5 low-order digits immediately after d-09 is opened. The display shifts to high-order digits by pressing ◁ to allow checking high-order digits. (A decimal point is placed between high-order word and low-order word.)
d-10	Output voltage monitor	0 to 400 [V]	Displays the output voltage in 1V units.
d-11	Trip monitor	Displays the last alarm, speed command value, speed detection value, current value, and DC bus voltage. Data is displayed in the following sequence each time ◁ is pressed. Alarm number : E01-1, etc. (Last digit of -1 indicates the latest information.) Speed command value : –5000 (Contains no period.) Speed detection value : –5000. (Contains a period.) Current value : 4.60A DC bus voltage : 270u Input terminal information : Complies with d-05 display. Output terminal information: Complies with d-06 display.	
d-12	Trip log monitor	Refer to the example shown on the right.	Displays the past 3 alarm logs except the latest log. Pressing △ or ▽ displays the alarm number only. Pressing ◁ displays the alarm information. Alarm number : E01-2, etc. (The larger the last digit, the older the log.) Speed command value : –5000 (Contains no period.) Speed detection value : –5000. (Contains a period.) Current value : 4.60A DC bus voltage : 270u Input terminal information : Complies with d-05 display. Output terminal information : Complies with d-06 display.

<table>
<tr><th>Monitor No.</th><th>Monitor name</th><th>Display range</th><th>Description</th></tr>
<tr><td>d-13</td><td>Operation control mode monitor</td><td>trq (torque control)
SPd (speed control)
PoS (position control)</td><td>Displays the current operation mode.</td></tr>
<tr><td>d-14</td><td>Operation status monitor</td><td>non (normal stop)
run (run)
trP (error)
Fot (forward overtravel)
rot (reverse overtravel)
ot (run inhibit stop)</td><td>Displays the robot driver operation status as shown below.
<table>
<tr><th rowspan="2">d-14 display</th><th colspan="3">Terminal status</th><th rowspan="2">Remarks</th></tr>
<tr><th>SON</th><th>Fot</th><th>rot</th></tr>
<tr><td rowspan="3">non</td><td rowspan="3">OFF</td><td>ON</td><td>ON</td><td rowspan="3">Stop status</td></tr>
<tr><td>OFF</td><td>ON</td></tr>
<tr><td>ON</td><td>OFF</td></tr>
<tr><td>run</td><td>ON</td><td>ON</td><td>ON</td><td>Servo ON status</td></tr>
<tr><td>trP</td><td>–</td><td>–</td><td>–</td><td>Alarm status</td></tr>
<tr><td>Fot</td><td>ON</td><td>OFF</td><td>ON</td><td>Forward run inhibit and servo ON status</td></tr>
<tr><td>rot</td><td>ON</td><td>ON</td><td>OFF</td><td>Reverse run inhibit and servo ON status</td></tr>
<tr><td>ot</td><td>–</td><td>OFF</td><td>OFF</td><td>Forward/ reverse run inhibit</td></tr>
</table></td></tr>
<tr><td>d-15</td><td>Detected moment-of-inertia monitor</td><td>"Motor rotor inertia" to "motor rotor inertia × 128"
RDX [× 10^{-4}kg·m^2]
RDP [× 10 kg]</td><td>Displays the moment-of-inertia and mover mass specified by parameter Fd-00.</td></tr>
<tr><td>d-16</td><td>Phase Z position monitor (Magnetic pole position counter monitor)</td><td>0 to 8192
(Maximum value is equal to FC-09.)
[pulses]</td><td>Displays the position monitor showing the phase Z position. The position of phase Z is set to "monitor display = 0".
Count increases in the forward run direction according to the direction set by FA-14. The maximum on this monitor is equal to FC-09.</td></tr>
<tr><td>d-17</td><td>Do not use.</td><td>—</td><td>Do not use.</td></tr>
<tr><td>d-18</td><td>Machine reference</td><td>0 to 100
[%]</td><td>Displays the machine reference after return-to-origin is performed using the sensor method or stroke end method.</td></tr>
<tr><td>d-32</td><td>Regenerative braking operating ratio monitor</td><td>0 to 100
[%]</td><td>Displays the duty ratio of the regenerative braking resistor in 5 seconds with 100% being equal to the alarm level (set by FA-08).
Example : When FA-08 is set to 0.5 (%), an alarm trips if the regenerative braking resistor works for 25ms in 5 seconds, (5 × 0.005 = 0.025). The monitor value shows 100% at this point.</td></tr>
</table>

6.3.2 Setup parameter description

(1)Operation mode parameters, etc.

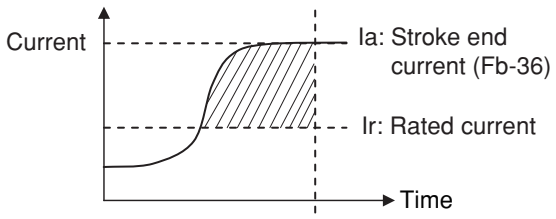
Parameter No.	Parameter name	Setting range [Default value]	Description
FA-00	Control mode	S-P, P-S,S-t, t-S,t-P, P-t [P-S]	Set this parameter to "P-S (position control)".
FA-01	Position sensor wire breaking detection	on, OFF [on]	Selects whether to make an alarm trip when a position sensor error occurs (or wire breakage or open circuit fault is detected). When this parameter is set to "on", an alarm trips if a position sensor error (E39) is detected. When set to "OFF" no alarm will trip even if a position sensor error (E39) occurs. Even when set to "OFF", a position sensor error (E39) occurs if a counter error is detected by the position sensor. A position sensor error (E39) also occurs at servo ON if power has been turned on without the position sensor connected, regardless of this parameter setting. Set this parameter to "on" in normal operation, and do not set to "OFF" except in case of emergency.
FA-02	Allowable time of power failure	0.00, 0.05 to 1.00 (s) [0.00]	Sets the allowable time for momentary power outage (main circuit power supply shut-off, main circuit power supply open-phase, insufficient main circuit power supply voltage). When this parameter is set to 0.00, the above momentary power outage is not detected.
FA-03	Overspeed error detection level	0 to 150 (%) [110]	When the detected speed value becomes abnormally high compared to the maximum speed, an alarm trips as an overspeed error. This parameter specifies the threshold level for detecting the overspeed error as a percentage of the maximum rotational speed of the robot. When set to 0, overspeed errors are not detected.
FA-04	Speed error detection value	0 to maximum speed *1 RDX (min^{-1}) RDP (mm/s) [Depends on model]	When the speed error (difference between speed command value and speed detection value) becomes abnormally large, an alarm trips as a speed error. This parameter specifies the threshold value for detecting the speed error. When set to 0, speed errors are not detected.
FA-05	Position error detection value	0.0 to 100.0 (rotations) [20.0]	When the position error (difference between position command value and position detection value) becomes abnormally large, an alarm trips as a position deviation error. This parameter specifies the threshold value for detecting the position error in rotation units. When set to 0.0, no position deviation errors are detected.
FA-07	DC bus power supply	L123 Pn [L123]	This parameter sets the method for supplying the main power. When this parameter is set to "Pn", momentary power outage is not detected. Set this parameter to "L123". **Setting** / **Method for supplying main power** **L123** / Supply 3-phase AC power as the main power from terminals L1, L2 and L3.

*1: This is the maximum speed of the robot. Check the robot specifications.

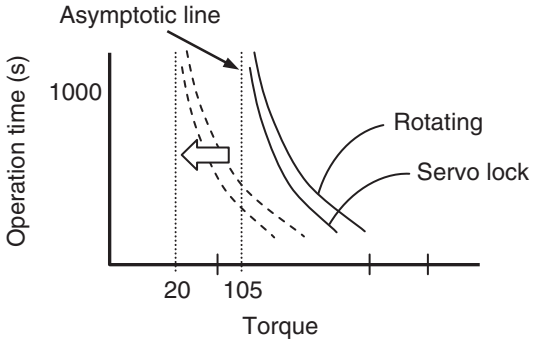
<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FA-08</td><td>Regenerative braking operating ratio</td><td>0.0 to 100.0
(%)
[Depends on model]</td><td>Use this parameter to set the duty ratio of the regenerative braking resistor for 5 seconds. An alarm trips if the regenerative braking time exceeds this setting. (See table below.)
When set to 0.0, no alarm due to the duty ratio will trip. Set this parameter value when using an external braking resistor with overheat protection, which is different from the external braking resistors available from YAMAHA as options.
When not connecting an external braking resistor, set the allowable duty ratio of the internal braking resistor shown in the table. When using an optional external braking resistor, set the allowable braking frequency value by referring to 10.1, "Options".
<table>
<tr><th colspan="2">Robot driver output</th><th>Allowable duty ratio of internal braking resistor</th></tr>
<tr><td rowspan="2">3-phase 200V</td><td>RD*-05, 10</td><td>Other than 0.0%</td></tr>
<tr><td>RD*-20, RDP-25</td><td>0.5%</td></tr>
</table>
Note: When making the FA-08 setting, always set a value that matches the internal or external braking resistance. If the setting is incorrect, the braking resistor may break down.</td></tr>
<tr><td>FA-09</td><td>Overload notice level</td><td>20 to 100
(%)
[80]</td><td>If the overload level exceeds the value set in this parameter, then the electronic thermal function outputs an overload warning signal.</td></tr>
<tr><td>FA-10</td><td>Auto tuning mode</td><td>non
oFL
onL1
FFt
onL2
[non]</td><td>Auto-tuning and mechanical system diagnosis are performed according to the setting of this parameter. Do not set this parameter to "onL1" and "onL2".
<table>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td>non</td><td>Does not perform auto-tuning.</td></tr>
<tr><td>oFL</td><td>Performs offline auto-tuning.
When servo is turned ON with this parameter set to "oFL", offline auto-tuning automatically starts. When auto-tuning is completed, the mover mass is automatically set and this parameter is reset to "non".</td></tr>
<tr><td>FFt</td><td>Performs mechanical system diagnosis.
When the servo is turned ON with this parameter set to "FFt", an FFT analysis is performed by moving the robot in a vibrational motion, and the transmission characteristics of the user's mechanical system are displayed. After the operation is completed, this parameter is reset to "non".
(Make this setting via the TOP software. Operation will not be correct if this setting is made only on the robot driver.)</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FA-11</td><td>Pulse train input mode</td><td>F-r
P-S
A-b
r-F
-P-S
b-A
[F-r]</td><td>Use this parameter to select the pulse train position command signal mode from among the following 6 modes.
<table>
<tr><th>Setting</th><th>Pulse train position command signal mode</th></tr>
<tr><td>F-r</td><td>PLS : Gives the motion amount in the forward direction in pulse trains.
SIG : Gives the motion amount in the reverse direction in pulse trains.</td></tr>
<tr><td>P-S</td><td>PLS : Gives the motion amount in pulse trains.
SIG : Set to OFF when moving in the forward direction or set to ON when in the reverse direction.</td></tr>
<tr><td>A-b</td><td>PLS : Input phase A of phase difference 2-phase signal.
SIG : Input phase B of phase difference 2-phase signal.</td></tr>
<tr><td>r-F</td><td>PLS : Gives the motion amount in the reverse direction in pulse trains.
SIG : Gives the motion amount in the forward direction in pulse trains.</td></tr>
<tr><td>-P-S</td><td>PLS : Give the motion amount in pulse trains.
SIG : Set to ON when moving in the forward direction or set to OFF when in the reverse direction.</td></tr>
<tr><td>b-A</td><td>PLS : Input phase B of phase difference 2-phase signal.
SIG : Input phase A of phase difference 2-phase signal.</td></tr>
</table></td></tr>
<tr><td>FA-12</td><td>Electronic gear numerator</td><td rowspan="2">1 to 65535
RDX
[Depends on model]
RDP
[1]</td><td rowspan="2">To input a pulse train position command, set the electronic gear ratio applied to the command value. The gear ratio is given by (FA-12) / (FA-13). The numerator and denominator can be set separately. The settings must meet the following condition:
1/20 ≤ (FA-12) / (FA-13) ≤ 50
The FLIP-X series resolution is 16384 pulses per revolution of the motor, and the PHASER series resolution is 1 pulse per micrometer. The default values are set so as to issue a command of 1μm per pulse.</td></tr>
<tr><td>FA-13</td><td>Electronic gear denominator</td></tr>
<tr><td>FA-14</td><td>Motor revolution direction</td><td>CC
C
[Depends on model]</td><td>Use this parameter to change the forward direction of the motor.
<table>
<tr><th>Setting</th><th>Forward direction of motor</th></tr>
<tr><td>CC</td><td>The counterclockwise direction as viewed from the motor output shaft end is specified as the forward direction.</td></tr>
<tr><td>C</td><td>The clockwise direction as viewed from the motor output shaft end is specified as the forward direction.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FA-16</td><td>DB Operation selection</td><td>non
trP
SoF
[SoF]</td><td>Set the condition for applying the dynamic brake.
<table>
<tr><th>Setting</th><th>Condition for applying dynamic brake</th></tr>
<tr><td>non</td><td>Does not use the dynamic brake.</td></tr>
<tr><td>trP</td><td>Applies the dynamic brake only when an alarm has tripped.</td></tr>
<tr><td>SoF</td><td>Applies the dynamic brake when the servo ON terminal is turned off (including an alarm). (Note 1)</td></tr>
</table>
Note 1: The dynamic brake is for emergency stop. Do not perform start or stop by turning the servo ON terminal to ON or OFF. Always turn the servo off after the robot has stopped.
Note 2: Regardless of this parameter setting, the dynamic brake is applied when the voltage of the main circuit power supply becomes too low while the control power supply is ON.(RD*-5, 10, and 20)</td></tr>
<tr><td>FA-17</td><td>Torque limit mode</td><td>non
A2
oP
[non]</td><td>Sets the input source of the torque limit value and the torque limit mode. Set this parameter to "non".
<table>
<tr><th>Setting</th><th>Torque limit mode</th></tr>
<tr><td>non</td><td>Limits the torque according only to the 4 quadrant torque limit values (Fb-07 to Fb-10).</td></tr>
</table></td></tr>
<tr><td>FA-18</td><td>Torque bias mode</td><td>non
CnS
A2
oP
[non]</td><td>Sets the input source of torque bias value. Do not set this parameter to "A2" or "oP".
<table>
<tr><th>Setting</th><th>Torque bias mode</th></tr>
<tr><td>non</td><td>Does not use a torque bias.</td></tr>
<tr><td>CnS</td><td>Applies a bias using the set torque bias value (Fb-11).</td></tr>
</table></td></tr>
<tr><td>FA-20</td><td>Speed limit mode</td><td>non
A1
oP
[non]</td><td>Sets the input source of speed limit value and the torque limit mode. Set this parameter to "non".
<table>
<tr><th>Setting</th><th>Speed limit mode</th></tr>
<tr><td>non</td><td>Limits the speed according only to the set forward speed limit value and reverse speed limit value (Fb-20, Fb-21).</td></tr>
</table></td></tr>
<tr><td>FA-22</td><td>Position command selection</td><td>PLS
Pro
oP
[PLS]</td><td>Sets the input source of position command value. Set this parameter to "PLS".
<table>
<tr><th>Setting</th><th>Input source of position command</th></tr>
<tr><td>PLS</td><td>Controls the position with the pulse train command input as the command value.</td></tr>
</table></td></tr>
</table>

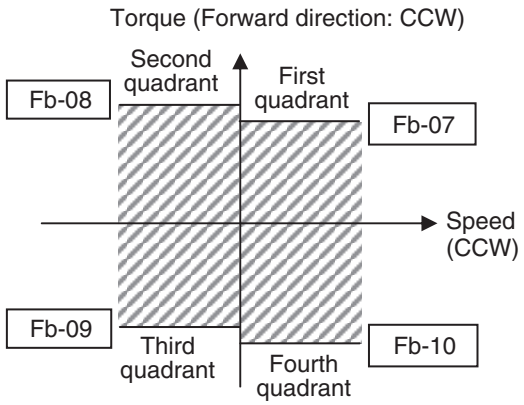
<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FA-23</td><td>Homing mode</td><td>L-F
L-r
H1-F
H1-r
H2-F
H2-r
CP
t-F
t-r
S-F
S-r
[Depends on model]</td><td>This parameter specifies the homing mode and return-to-origin direction.
<table>
<tr><th>Setting</th><th>Return-to-origin direction</th><th>Return-to-origin operation</th></tr>
<tr><td>L-F</td><td colspan="2" rowspan="7">Do not change.</td></tr>
<tr><td>L-r</td></tr>
<tr><td>H1-F</td></tr>
<tr><td>H1-r</td></tr>
<tr><td>H2-F</td></tr>
<tr><td>H2-r</td></tr>
<tr><td>CP</td></tr>
<tr><td>t-F</td><td>Forward run</td><td rowspan="2">Stroke end method</td></tr>
<tr><td>t-r</td><td>Reverse run</td></tr>
<tr><td>S-F</td><td>Forward run</td><td rowspan="2">Sensor method</td></tr>
<tr><td>S-r</td><td>Reverse run</td></tr>
</table>
When the return-to-origin mode (FA-23) is set to "stroke end method" (t-F, t-r), the robot driver determines whether the robot has reached its stroke end (mechanical end) as follows:
When the robot comes into contact with its stroke end during return-to-origin operation, the current increases. When the current exceeds the rated current Ir and the integrated current reaches the current Ia specified by the stroke-end current parameter (Fb-36) as shown below, the robot driver determines that the robot has reached its stroke end.
$\Sigma\left(Ia^2 - Ir^2\right) > \left(\left(\ Imax \times \frac{(Fb\text{-}36)}{100}\ \right)^2 - Ir^2\right) \times (Fb\text{-}37)$
 

Note: Return-to-origin operation stops and the servo locks when the ORG terminal is switched from ON to OFF.</td></tr>
<tr><td>FA-24</td><td>Servo OFF wait time</td><td>0.00 to 1.00
(s)
[0.05]</td><td>Sets the time from when Servo ON command is turned off until servo ON status is actually cleared.
Note: This parameter allows the servo to delay turning off until the specified wait time elapses after activating the brake. Set this wait time to counteract delays in the brake operation. Use this parameter as needed when stopping the robot such as after positioning is complete.</td></tr>
<tr><td>FA-25</td><td>Operation range at machine diagnosis</td><td>1 to 255
(rotations)
[10]</td><td>Set the allowable rotation range of the robot during mechanical system diagnosis. Mechanical systems are diagnosed in the positive/negative range of the allowable setting range.</td></tr>
</table>

Parameter No.	Parameter name	Setting range [Default value]	Description
FA-26	Brake operation start speed * Valid only for robot with mechanical brake.	0 to maximum speed RDX (min^{-1}) RDP (mm/s) [30]	If the speed becomes lower than the set speed after the Servo ON command is turned off or an alarm has tripped, the brake signal (BRK) activates the brake. If the time set in FA-27 elapses before the speed becomes lower than the set speed, the BRK signal also works to activate the brake.
FA-27	Brake operation start time * Valid only for robot with mechanical brake.	0, 0.004 to 1.000 (s) [0]	Sets the maximum time from when the Servo ON command is turned off or an alarm has tripped until the brake signal (BRK) works to activate the brake. The time can be set in 4ms steps. If the speed becomes lower than the setting in FA-26 after turning off the Servo ON command, then the BRK signal activates the brake, regardless of this setting (FA-27).
FA-28	Electronic thermal level	20 to 105 (%) [Depends on model]	Sets the electronic thermal level. Change the thermal level so that it matches the ambient temperature and robot operating conditions. When this parameter is changed, the asymptotic line can be moved in parallel with the operation time as shown below. Set this parameter to the default value for each model. 
FA-80	Position sensor type selection	inC AbS [inC]	When an absolute position sensor is used, this parameter specifies the position sensor type. Set this parameter to "inC".
FA-81	Position sensor selection	Stnd inCE AbSE1 AbSE2 AbSA2 AbSA4 [inCE]	This parameter specifies the position sensor type . Set this parameter to "inCE". Note 1: A "Mismatch error (E40)" occurs if this parameter is set incorrectly. Note 2: This setting is enabled by turning power off and then back on. Note 3: This parameter is not reset by user initialization.
FA-82	Position sensor resolution	500 to 65535 (pulses) RDX [4096] RDP [Depends on model]	Sets the number of pulses per rotation of the position sensor. Set this parameter to the default value for each model.
FA-85	Linear scale accuracy * Valid only for RDP.	0.01 to 655.35 (μm) [1.00]	Sets the machine length equivalent to 1 pulse of ×4 signal on the linear scale. Set this parameter to "1.00".

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FA-86</td><td>Pole position offset
* Valid only for RDP.</td><td>8000 to 7FFF
[0]</td><td>Specifies the phase Z distance used as the reference and zero crossing (rising) for the induced voltage of phase U or across U and V. Set this parameter in signed hexadecimal of 16-bit length. By quantizing this setting, the 180° electrical angle of the linear motor will be H'4000 (hexadecimal).
Use FA-88 to set the type of reference voltage (phase voltage or line voltage).</td></tr>
<tr><td>FA-87</td><td>Linear scale polarity
* Valid only for RDP.</td><td>A, b
[b]</td><td>Sets the phase direction in the forward run of the linear scale. Set this parameter to "b".
<table><tr><th>Setting</th><th>Phase</th></tr><tr><td>b</td><td>Phase B leads phase A.</td></tr></table></td></tr>
<tr><td>FA-88</td><td>Phase angle of pole position
* Valid only for RDP.</td><td>PHASE,
LinE
[PHASE]</td><td>Sets whether the phase of magnetic pole position signal is the same as the phase voltage or line voltage of the linear motor induced voltage. The offset specified by parameter FA-86 is relative to this parameter setting. Set this parameter to "PHASE".
<table><tr><th>Setting</th><th>Phase</th></tr><tr><td>PHASE</td><td>• Magnetic pole position signal has the same phase as phase voltage.
• FA-86 is relative to the induced voltage of phase U.</td></tr></table></td></tr>
<tr><td>FA-89</td><td>Preset condition for pole position
* Valid only for RDP.</td><td>OrLP,
OrLn
[OrLP]</td><td>Sets the condition for presetting the magnetic pole position. Set this parameter to "OrLP".
<table><tr><th>Setting</th><th>Preset condition</th></tr><tr><td>OrLP</td><td>Preset at the first phase Z position after the ORL signal is switched from OFF to ON.</td></tr></table></td></tr>
<tr><td>FA-90</td><td>Hall sensor connection
* Valid only for RDP.</td><td>oFF,
CnCt,
oFF2
[oFF2]</td><td>Sets the sequence of magnetic pole position estimation operation. Use this parameter by setting to "oFF2".
<table><tr><th>Setting</th><th>Description</th></tr><tr><td>oFF2</td><td>Starts magnetic pole position estimation only when the SON terminal is first switched from OFF to ON after power-on.</td></tr></table>Note 1: When set to "oFF2", the RS terminal is enabled only when resetting an alarm after it has tripped.</td></tr>
<tr><td>FA-98</td><td>Initialization mode selection</td><td>CH
dAtA
AbS
[CH]</td><td>Use this parameter to select whether to clear the alarm/trip log or to initialize the user data. Do not set this parameter to "AbS".
<table><tr><th>Setting</th><th>Description</th></tr><tr><td>CH</td><td>Clears the alarm/trip log.
Cancels the monitor of a specific parameter (d-xx) that is automatically displayed at power-on.</td></tr><tr><td>dAtA</td><td>Initializes the user data.</td></tr></table></td></tr>
</table>

(2)Operation constant parameters

Parameter No.	Parameter name	Setting range [Default value]	Description
Fb-04	Speed acceleration time	0.00 to 99.99 (s) [10.00]	Sets the acceleration/deceleration time to perform return-to-origin. Set the time needed to accelerate from 0 to the maximum motor speed (or time needed to decelerate from maximum motor speed to 0).
Fb-05	Speed deceleration time		
Fb-07	Torque limit value 1	0 to maximum torque (%) [Depends on model]	Sets the torque limit value for each quadrant. Torque limit values 1, 2, 3, and 4 correspond to the first quadrant through fourth quadrant. Set an absolute value for all quadrants. Movement direction is same for Fb-07 to Fb10. 
Fb-08	Torque limit value 2		
Fb-09	Torque limit value 3		
Fb-10	Torque limit value 4		
Fb-11	Torque bias value	±0 to ±300 (%) [0]	When setting the torque bias to a fixed value, specify it with this parameter. In this case, FA-18 must be set to "CnS". Set the bias value in the ratio to the rated torque defined as 100%.
Fb-12	Homing speed 1 (Fast)	RDX 1 to maximum speed *1 (min^{-1}) [60] RDP 1 to 100 (mm/s) [20]	Sets the fast speed to perform return-to-origin.
Fb-13	Homing speed 2 (Slow)	RDX 1 to 999 (min^{-1}) [6] RDP 1 to 20 (mm/s) [5]	Sets the slow speed to perform return-to-origin.
Fb-14	Offset position (H/L) at return-to-origin (homing)	±0 to ±19999 *2 (pulses) [0]	Sets the offset position to perform return-to-origin. Ten-digit data consisting of high-order digits specified by Fb-14 and lower-order digits specified by Fb-15 is used to determine the offset position during return-to-origin.
Fb-15		0 to 99999 (pulses) [0]	

*1: This is the maximum speed of the robot. Check the robot specifications.

*2: Methods for displaying and entering these parameter values (–10000 to –19999) differ from other methods. For the operation method, refer to "(3) Special display" in section 6.1.2, "Operating the digital operator".

Parameter No.	Parameter name	Setting range [Default value]	Description
Fb-16	Forward position limit value (H/L)	±0 to ±19999 *2 (pulses) [0]	Sets the drive range in the forward (+) direction. Ten-digit data (number of position sensor pulses) consisting of high-order digits specified by Fb-16 and lower-order digits specified by Fb-17 is used to determine the forward (+) position limit value. No limit is in effect when these parameters are set to 0. Note: Refer to precautions on Fb-18 and Fb-19.
Fb-17		0 to 99999 (pulses) [0]	
Fb-18	Reverse position limit value (H/L)	±0 to ±19999 *2 (pulses) [0]	Sets the drive range in the reverse (–) direction. No limit is in effect when these parameters are set to 0. Note: In the following case, the setting is invalid and the motor operates with no limit. Position limit value (+) ≤ Position limit value (–) (Fb-16: Fb-17) (Fb-18: Fb-19)
Fb-19		0 to 99999 (pulses) [0]	
Fb-20	Forward speed limit value	0 to maximum speed *1 RDX (min^{-1}) RDP (mm/s) [Depends on model]	Sets the upper speed limit.
Fb-21	Reverse speed limit value	-maximum speed to 0 RDX (min^{-1}) RDP (mm/s) [Depends on model]	
Fb-23	Positioning detection range	1 to 65535 (pulses) [20]	Sets the threshold value for position deviation (difference between position command value and position detection value) used to determine whether positioning is complete.
Fb-24	Positioning interval time limit	0.00 to 10.00 (s) [0.00]	Sets the threshold value for the time difference between position command value and position detection value (time required for position detection value to reach the position command value) used to determine whether positioning is complete. When set to 0.00, no monitoring is performed. This parameter can be set in 0.02 steps.
Fb-25	Up to speed detection range	0 to 100 RDX (min^{-1}) RDP (mm/s) [10]	Sets the threshold value for the speed deviation (difference between speed command value and speed detection value) used to determine whether the specified speed is reached.
Fb-30	S-curve ratio	non SHArP rEGLr LooSE [non]	Set this parameter to "non".
Fb-35	Homing back distance	1 to 255 [Depends on model]	Sets the distance the robot moves back from the mechanical end after detecting it during return-to-origin operation using the stroke end method.

*1: This is the maximum speed of the robot. Check the robot specifications.

*2: Methods for displaying and entering these parameter values (–10000 to –19999) differ from other methods. For the operation method, refer to "(3) Special display" in section 6.1.2, "Operating the digital operator".

Parameter No.	Parameter name	Setting range [Default value]	Description
Fb-36	Current for striking limit	40 to 100 (%) [Depends on model]	Sets the stroke-end current that is detected when the robot comes into contact with its mechanical end during return-to-origin operation using the stroke end method.
Fb-37	Time for striking limit	0.1 to 2.0 (s) [0.2]	Sets the time during which the mechanical end is detected during return-to-origin operation using the stroke end method.
Fb-40 (Note 1)	Pole position estimation speed * Valid only for RDP.	–500 to 500 (mm/s) [Depends on model]	Sets the speed command value during magnetic pole position estimation.
Fb-41 (Note 1)	Pole position estimation ACC/DEC time * Valid only for RDP.	10 to 500 (ms) [Depends on model]	Sets the acceleration/deceleration time during magnetic pole position estimation.
Fb-42 (Note 1)	Pole position estimation wait time * Valid only for RDP.	0 to 500 (ms) [100]	Sets the time interval during magnetic pole position estimation.
Fb-43 (Note 1)	Pole position estimation constant-speed time * Valid only for RDP.	0 to 500 (ms) [Depends on model]	Sets the constant-speed time during magnetic pole position estimation.
Fb-44 (Note 1)	Position sensor wire breaking detection current * Valid only for RDP.	20 to 100 (%) [Depends on model]	Set the current to be applied for detecting the position sensor wire breakage. If this parameter is set to 100 [%], then the motor rated current will be applied.
Fb-45 (Note 1)	Speed error detection value at pole position estimation * Valid only for RDP.	0 to maximum speed (mm/s) [500]	Set the speed deviation error detection value during magnetic pole position estimation. When set to 0, speed deviation errors will not be detected.

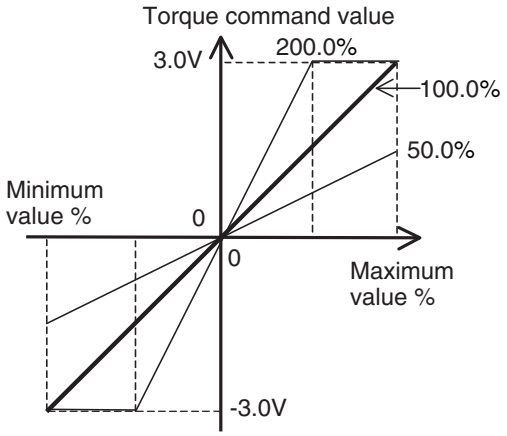
Note 1: Displayed on the RDP only.

(3)Input/output terminal parameters

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FC-01</td><td>Input terminal polarity setting</td><td>0000 to 3FFF [0400]</td><td>
Sets the ON/OFF logic for the input terminals.
(Usually the logic is positive so the function turns on when the external contact is closed.)
The logic setting for each terminal is assigned to each bit of the parameter to set the logic as follows.
<table>
<tr><th>Bit setting</th><th>Input terminal logic</th></tr>
<tr><td>0</td><td>Positive logic: Function turns on when the external contact is closed.</td></tr>
<tr><td>1</td><td>Negative logic: Function turns on when the external contact is opened.</td></tr>
</table>
The following tables show input terminals and bit assignment by this parameter.
<table>
<tr><th>bit 15</th><th>bit 14</th><th>bit 13</th><th>bit 12</th></tr>
<tr><td>O
Assigned not</td><td>O
Assigned not</td><td>CER</td><td>PEN</td></tr>
</table>
<table>
<tr><th>bit 11</th><th>bit 10</th><th>bit 9</th><th>bit 8</th></tr>
<tr><td>ORG</td><td>ORL</td><td>Assigned not</td><td>Assigned not</td></tr>
</table>
<table>
<tr><th>bit 7</th><th>bit 6</th><th>bit 5</th><th>bit 4</th></tr>
<tr><td>Assigned not</td><td>Assigned not</td><td>ROT</td><td>FOT</td></tr>
</table>
<table>
<tr><th>bit 3</th><th>bit 2</th><th>bit 1</th><th>bit 0</th></tr>
<tr><td>TL</td><td>Assigned not</td><td>RS</td><td>SON</td></tr>
</table>
</td></tr>
<tr><td>FC-02</td><td>Output terminal polarity setting</td><td>0000 to 00FF [0002]</td><td>
Sets the ON/OFF logic for the output terminals.
(Usually the logic is positive so the contact output turns on when the output function is ON.)
The logic setting for each terminal is assigned to each bit of the parameter to set the logic as follows.
<table>
<tr><th>Bit setting</th><th>Output terminal logic</th></tr>
<tr><td>0</td><td>Positive logic: The contact output turns on when the output function is ON.</td></tr>
<tr><td>1</td><td>Negative logic: The contact output turns off when the output function is ON.</td></tr>
</table>
The following tables show output terminals and bit assignment by this parameter.
<table>
<tr><th>bit 15</th><th>bit 14</th><th>bit 13</th><th>bit 12</th></tr>
<tr><td>O
Assigned not</td><td>O
Assigned not</td><td>O
Assigned not</td><td>O
Assigned not</td></tr>
</table>
<table>
<tr><th>bit 11</th><th>bit 10</th><th>bit 9</th><th>bit 8</th></tr>
<tr><td>O
Assigned not</td><td>O
Assigned not</td><td>O
Assigned not</td><td>O
Assigned not</td></tr>
</table>
<table>
<tr><th>bit 7</th><th>bit 6</th><th>bit 5</th><th>bit 4</th></tr>
<tr><td>Assigned not</td><td>Assigned not</td><td>BRK</td><td>Assigned not</td></tr>
</table>
<table>
<tr><th>bit 3</th><th>bit 2</th><th>bit 1</th><th>bit 0</th></tr>
<tr><td>Assigned not</td><td>INP</td><td>ALM</td><td>SRD</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FC-09</td><td>Position sensor monitor resolution M</td><td>16 to 8192
[1]</td><td rowspan="2">Sets the division ratio M/N of the position sensor monitor signal. This setting's description changes in relation to the type of position sensor. A "Mismatch error (E40)" occurs without outputting position sensor monitor signals if invalid combinations are set as listed in the following table. This parameter is enabled by turning power off and then back on.
<table>
<tr><th rowspan="2">Position sensor selection FA-81</th><th colspan="2">Effective range</th><th rowspan="2">Position sensor monitor division radio</th><th rowspan="2">Invalid combination</th></tr>
<tr><th>M</th><th>N</th></tr>
<tr><th></th><th>FC-09</th><th>FC-10</th><th></th><th></th></tr>
<tr><td rowspan="3">inCE</td><td>(Note 2)
1</td><td>1 to 64</td><td>1/N</td><td>FC-10=
65 to 8192</td></tr>
<tr><td>(Note 2)
2</td><td>3 to 64</td><td>2/N</td><td>FC-10=
1, 2, 65 to 8192</td></tr>
<tr><td>1 to 8191</td><td>(Note 1)
8192</td><td>M/8192</td><td>FC-09=8192
FC-10=
1 to 8191</td></tr>
</table>
Note 1: The position sensor monitor division ratio is set to "M/8192" when FC-10 is not equal to 8192. In all other cases, the position sensor monitor division ratio is set to "1/N" or "2/N" according to FC-09.
Note 2: The FLIP-X series resolution is 16384 pulses per revolution of the motor.
The PHASER series resolution is 1 pulse per micrometer.</td></tr>
<tr><td>FC-10</td><td>Position sensor monitor resolution N</td><td>1 to 8192
RDX [4]
RDP [1]</td></tr>
<tr><td>FC-11</td><td>Position sensor monitor polarity</td><td>A
b
[b]</td><td>This parameter specifies which phase of the position sensor signal, phase A or phase B, leads the other phase when the motor runs forward. Set this parameter to "b".
<table>
<tr><th>Setting</th><th>Phase relation</th></tr>
<tr><td>b</td><td>Phase B leads phase A.</td></tr>
</table>
This parameter is enabled by turning power off and then back on.</td></tr>
<tr><td>FC-12</td><td>Phase Z output selection</td><td>1PLS
nCunt
ECunt
qFort
[1PLS]</td><td>Sets the OZP and OZN terminal outputs. Set this parameter to "1PLS".</td></tr>
<tr><td>FC-19</td><td>Command pulse filter time constant</td><td>Lo
Hi
[Hi]</td><td>Sets the pulse train filter time constant as follows.
<table>
<tr><th>Setting</th><th>Filter time constant</th></tr>
<tr><td>Lo</td><td>1 µs</td></tr>
<tr><td>Hi</td><td>0.2 µs</td></tr>
</table></td></tr>
<tr><td>FC-21</td><td>Communication baud rate</td><td>1200, 2400,
4800, 9600,
19200, 38400
[bps]
[19200]</td><td>Sets the baud rate used to communicate with the PC (TOP software for RD series).</td></tr>
<tr><td>FC-22</td><td>Communication bit length</td><td>7,8
[bit]
[8]</td><td>Sets the bit length used to communicate with the PC (TOP software for RD series).</td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FC-23</td><td>Communication parity</td><td>non, odd, EvEn
[non]</td><td>Sets the parity f used to communicate with the PC (TOP software for RD series).
<table><tr><th>Setting</th><th>Description</th></tr><tr><td>non</td><td>Communication parity: none</td></tr><tr><td>odd</td><td>Communication parity: odd</td></tr><tr><td>EvEn</td><td>Communication parity: even</td></tr></table>After this parameter is changed, turn power off and then back on to enable the change. Otherwise, a malfunction will occur.</td></tr>
<tr><td>FC-24</td><td>Communication stop bit</td><td>1, 2
[2]</td><td>Sets the stop bit used to communicate with the PC (TOP software for RD series).</td></tr>
<tr><td>FC-30</td><td>Monitor output 1 function</td><td>nrF, nFb, iFb, tqr, nEr, PEr, PFq, brd
[nFb]</td><td rowspan="2">Sets the data items to be output as the monitor outputs 1 and 2 as shown in the table below. "yes" indicates that the corresponding value is output, and "no" indicates that 0V is output. The data items shown in the "3V output value" column are available when the monitor output gains 1 and 2 are 100.0.
<table><tr><th rowspan="2">Setting</th><th rowspan="2">Data item</th><th rowspan="2">3.0V output value</th><th colspan="3">Control mode</th></tr><tr><th>Position</th><th>Speed</th><th>Torque</th></tr><tr><td>nFb</td><td>Speed detection value</td><td>Maximum speed</td><td>yes</td><td>yes</td><td>yes</td></tr><tr><td>tqr</td><td>Torque command value</td><td>Maximum torque</td><td>yes</td><td>yes</td><td>yes</td></tr><tr><td>nrF</td><td>Speed command value</td><td>Maximum speed</td><td>yes</td><td>yes</td><td>no</td></tr><tr><td>nEr</td><td>Speed deviation</td><td>Maximum speed</td><td>yes</td><td>yes</td><td>no</td></tr><tr><td>PEr</td><td>Position deviation</td><td>Five motor rotations</td><td>yes</td><td>no</td><td>no</td></tr><tr><td>iFb</td><td>Current value</td><td>Maximum current</td><td>yes</td><td>yes</td><td>yes</td></tr><tr><td>PFq</td><td>Command pulse frequency</td><td>Maximum speed</td><td>yes</td><td>no</td><td>no</td></tr><tr><td>brd</td><td>Regenerative braking resistor duty ratio</td><td>Trip level (FA-08)</td><td>yes</td><td>yes</td><td>yes</td></tr></table>Note: When an alarm has tripped, 0V is output from all data items except the speed detection value. However, if a position sensor error (E39) occurs then the speed detection value is no longer fixed.</td></tr>
<tr><td>FC-33</td><td>Monitor output 2 function</td><td>nrF, nFb, iFb, tqr, nEr, PEr, PFq, brd
[tqr]</td></tr>
<tr><td>FC-31</td><td>Monitor output 1 polarity</td><td rowspan="2">SiGn, AbS
[SiGn]</td><td rowspan="2">This parameter specifies whether to output data from monitor outputs 1 and 2 in a range of 0 to ±3.0V or 0 to 3.0V.
<table><tr><th>Setting</th><th>Description</th></tr><tr><td>SiGn</td><td>0 to ±3.0V (Note)</td></tr><tr><td>AbS</td><td>0 to 3.0V</td></tr></table>Note: The output is positive only when FC-30 and FC-33 are set to "PFq" or "brd".</td></tr>
<tr><td>FC-34</td><td>Monitor output 2 polarity</td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>FC-32</td><td>Monitor output 1 gain</td><td rowspan="2">0.0 to 3000.0
(%)
[100.0]</td><td rowspan="2">Use these parameters to set the gain of monitor outputs 1 and 2. When set to 100.0, the voltage shown in the table for FC-30 and FC-33 is output. The following graph shows the relation between gain and output voltage (when FC-30 and FC-33 are set to "tqr").
 
</td></tr>
<tr><td>FC-35</td><td>Monitor output 2 gain</td></tr>
<tr><td>FC-40</td><td>Input terminal function</td><td>0 to 3FFF
[0]</td><td>This parameter specifies which of 1st function and 2nd function of the input terminal should be enabled. (0 = 1st function, 1 = 2nd function)
<table>
<tr><th>Setting</th><th>b13</th><th>b12</th><th>b11</th><th>b10</th><th>b9</th><th>b8</th></tr>
<tr><td>0</td><td>CER</td><td>PEN</td><td>ORG</td><td>ORL</td><td>–</td><td>–</td></tr>
<tr><td>1</td><td colspan="4">Does not function.</td><td>–</td><td>–</td></tr>
</table>
<table>
<tr><th>Setting</th><th>b7</th><th>b6</th><th>b5</th><th>b4</th><th>b3</th><th>b2</th><th>b1</th><th>b0</th></tr>
<tr><td>0</td><td>–</td><td>–</td><td>ROT</td><td>FOT</td><td>TL</td><td>–</td><td>RS</td><td>SON</td></tr>
<tr><td>1</td><td>–</td><td>–</td><td>FOT</td><td>ROT</td><td>Does not function.</td><td>–</td><td colspan="2">Does not function.</td></tr>
</table>
Note 1: When either of b4 or b5 of FC40 is set to 1, b4 functions as FOT and b5 as FOT.
Note 2: The FOT and ROT terminal functions do not change even if the FA-14 (Motor revolution direction) setting is changed. FOT prohibits counterclockwise direction and ROT prohibits clockwise direction.
Note 3: After FA-14 or FC-40 setting is changed, turn power off and then back on to enable the change.</td></tr>
<tr><td>FC-70</td><td>Debug mode selection</td><td>0
[0]</td><td>Set this parameter to "0".</td></tr>
</table>

(4)Control constant parameter

Parameter No.	Parameter name	Setting range [Default value]	Description
Fd-00	Moment of inertia (RDX)	"Motor rotor inertia" to "motor rotor inertia × 128" RDX (×10^{-4}kg·m^2) RDP (×10kg) [Depends on model]	Use this parameter to set the entire mover mass including both rotary motor and load. This parameter can also be set automatically by auto-tuning.
	Mover mass (RDP)		Use this parameter to set the entire mover mass including both linear motor and load. This parameter can also be set automatically by auto-tuning.
Fd-01	Speed control cut-off frequency	0.1 to 500.0 (Hz) [Depends on model]	The speed control gain for speed PI control is calculated from the mover mass and this parameter setting. Usually set this parameter to a value close to the 3dB cut-off frequency obtained by measuring the frequency characteristic with a repetitive waveform when the speed control section performs PI control. When IP control is specified in Fd-05, the response speed becomes lower than the set value.
Fd-02	Speed control proportional gain	0.01 to 300.00 (%) [Depends on model]	Set this parameter to adjust the proportional gain used for speed PI control. When set to 100%, the proportional gain is set to the constant specified in Fd-00 and Fd-01. (Proportional gain) ∝ (Fd-00) × (Fd-01) × Fd-02 / 100
Fd-03	Speed control integral gain	0.01 to 300.00 (%) [Depends on model]	Set this parameter to adjust the integral gain used for speed PI control. When set to 100%, the integral gain is set to the constant specified in Fd-00 and Fd-01. (Integral gain) ∝ (Fd-00) × $(Fd\text{-}01)^2$ × Fd-03 / 100
Fd-04	P-control gain	0.1 to 99.9 (%) [Depends on model]	Set the gain used for speed P control. Set it by the torque (rated torque) to be output when a 1% speed deviation is provided.
Fd-05	IP-control gain	0.00 to 1.00 [Depends on model]	Use this parameter to continuously switch the speed feedback loop between PI and IP. When this parameter is set to 0, ordinary PI control is performed. At 1.00, IP control is performed. However, if this parameter (Fd-05) is set to a large value while Fd-00 and Fd-01 are large, then oscillation might occur. In this case, reduce Fd-02 to avoid such oscillation.
Fd-06	Torque command filter time constant	0.00 to 500.00 (ms) [Depends on model]	This parameter sets the time constant for the first-order lag filter to be applied to the torque command value. When this parameter is set to 0, no filtering is performed.
Fd-07	Position phase compensating ratio	0.01 to 9.99 [Depends on model]	Sets the compensation ratio for the phase lag filter to apply to the speed command value serving as the position control loop output. When this parameter exceeds 1, a phase lag occurs.
Fd-08	Position phase compensating time constant	0.1 to 999.9 (ms) [Depends on model]	Sets the compensation time constant for the phase lag filter to apply to the speed command serving as the position control loop output.
Fd-09	Position control cut-off frequency	0.01 to 99.99 (Hz) [Depends on model]	Sets the response frequency of the position feedback loop. Usually set this parameter to about 1/6 of the speed control cut-off frequency.
Fd-10	Position feed forward gain	0.00 to 1.00 [Depends on model]	Sets the ratio used to perform feed-forward compensation for the position control.
Fd-12	Notch filter 1 frequency	3.0 to 1000.0 (Hz) [Depends on model]	Sets the resonance frequency of notch filter 1. (Use TOP software to set this parameter.)
Fd-13	Notch filter 1 bandwidth	0 to 40 (dB) [Depends on model]	Sets the bandwidth of notch filter 1 at the resonance frequency. (Use TOP software to set this parameter.)

<table>
<tr><th>Parameter No.</th><th>Parameter name</th><th>Setting range [Default value]</th><th>Description</th></tr>
<tr><td>Fd-14</td><td>Notch filter 2 frequency</td><td>3.0 to 1000.0
(Hz)
[Depends on model]</td><td>Sets the resonance frequency of notch filter 1.
(Use TOP software to set this parameter.)</td></tr>
<tr><td>Fd-15</td><td>Notch filter 2 bandwidth</td><td>0 to 40
(dB)
[Depends on model]</td><td>Set the bandwidth of notch filter 2 at the resonance frequency.
(Use TOP software to set this parameter.)</td></tr>
<tr><td>Fd-20</td><td>Speed command filter time constant</td><td>0 to 60000
(ms)
[Depends on model]</td><td>Sets the time constant for the first-order lag filter to apply to the speed command value. When this parameter is set to 0, no filtering is performed.</td></tr>
<tr><td>Fd-30</td><td>Gain change mode</td><td>non
AUto
GCH
[Depends on model]</td><td>Sets the switching function in gain switch mode. Do not set this parameter to "GCH".<table><tr><th>Setting</th><th>Description</th></tr><tr><td>non</td><td>Gain does not change.</td></tr><tr><td>AUto</td><td>Gain changes automatically.</td></tr></table></td></tr>
<tr><td>Fd-31</td><td>Position error width for gain change</td><td>0 to 65535
[pulses]
[Depends on model]</td><td>Sets the threshold value of the position error width (difference between position command value and position detection value) used to start automatic gain change (Fd-30: AUto) in position control mode. Set this parameter in units of the number of position sensor pulses.</td></tr>
<tr><td>Fd-32</td><td>Second position control cut-off frequency</td><td>0.01 to 99.99
(Hz)
[Depends on model]</td><td>Sets the second position control cut-off frequency to perform gain change in position control mode.<table><tr><th>Fd-30 setting</th><th>Position error (d-09)</th><th>Cut-off frequency</th></tr><tr><td rowspan="2">AUto</td><td>(d-09) ≤ Fd-31</td><td>(Fd-32)</td></tr><tr><td>(d-09) > Fd-31</td><td>(Fd-09)</td></tr></table></td></tr>
<tr><td>Fd-33</td><td>Position gain change time constant</td><td>0.0 to 500.0
(ms)
[Depends on model]</td><td>Sets the gain change time constant to perform gain change in position control mode. When this parameter is set to 0, the gain changes immediately.</td></tr>
<tr><td>Fd-36</td><td>Position command filter time constant</td><td>0 to 60000
(ms)
[Depends on model]</td><td>Sets the time constant for the first-order lag filter to apply to a position command value. When this parameter is set to 0, no filtering is performed. Always set to 0 when performing -one-way continuous operation or one-way synchronous conveyor operation in position control mode. If not set to 0, a position error fault (E83) will occur.</td></tr>
<tr><td>Fd-40</td><td>Fast positioning mode</td><td>non
FASt
FoL
[Depends on model]</td><td>Sets the fast positioning mode to perform fast positioning in position control mode. When setting this parameter to "FASt" or "FoL", set the Moment of inertia (Fd-00) correctly.<table><tr><th>Setting</th><th>Description</th></tr><tr><td>non</td><td>Performs normal position control</td></tr><tr><td>FASt</td><td>Shortens the positioning settling time.</td></tr><tr><td>FoL</td><td>Performs minimum position error control.</td></tr></table></td></tr>
<tr><td>Fd-41</td><td>Position feed forward filter time constant</td><td>0.00 to 500.00
(ms)
[Depends on model]</td><td>Sets the time constant for the first-order lag filter used for position feed forward compensation in position control. When this parameter is set to 0, no filtering is performed.</td></tr>
<tr><td>Fd-42</td><td>Position error filter gain</td><td>0 to 100
(%)
[Depends on model]</td><td>Use this parameter to adjust the amount of position error which may occur during "minimum position error control" in position control mode.</td></tr>
<tr><td>Fd-44
(Note 1)</td><td>Speed feedback filter time constant</td><td>0.00 to 500.00
(ms)
[Depends on model]</td><td>Set the time constant for the first-order lag filter used for speed detection values.
When this parameter is set to 0, no filtering is performed.</td></tr>
</table>

Parameter No.	Parameter name	Setting range [Default value]	Description
Fd-46 (Note 1)	Mover mass for pole position estimation	"Robot mass" to "robot mass × 128" (× 10kg) [Depends on model]	Sets the mover mass during for pole position estimation.
Fd-47 (Note 1)	Speed control cut-off frequency for pole position estimation	0.1 to 500.0 (Hz) [Depends on model]	Sets the speed control cut-off frequency for magnetic pole position estimation.
Fd-48 (Note 1)	Gain change time constant after pole position estimation	0.0 to 500.0 (ms) [Depends on model	Sets the time constant of the first-order lag filter to reduce switching shock during control gain switching after the magnetic pole position estimation is completed.

Note 1: Displayed on RDP only.

6.3.3 Reference graph for setting the acceleration and position control cut-off frequency

For your reference, the following graphs show payload, acceleration, and position control cut-off frequency (Fd-09), plotted when the moment of inertia or mover mass (Fd-00), speed control cut-off frequency (Fd-01), and speed control integral gain (Fd-03) parameters are set to the specified values for each robot model. By referring to these graphs, set the position control cut-off frequency (Fd-09) and acceleration that match the required payload.

How to read graph

Example: T7-12

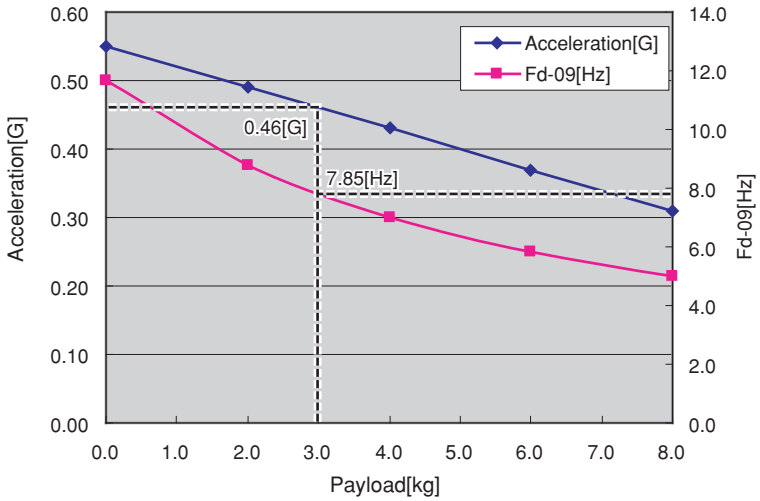
Model	T7-12

Maximum payload [kg] 8.0 [kg]

Fd-00 Moment of inertia 0.125 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.55	11.6
2.0	0.49	8.8
4.0	0.43	7.0
6.0	0.37	5.9
8.0	0.31	5.0

The above table shows examples for setting accelerations and position control cut-off frequencies (Fd-09) that match different payloads. If the required payload is not listed in this table, refer to the graph on the right.



Example: If a payload of 3kg is required, then the acceleration is 0.46 [G] and the position control cut-off frequency (Fd-09) is 7.85 [Hz].

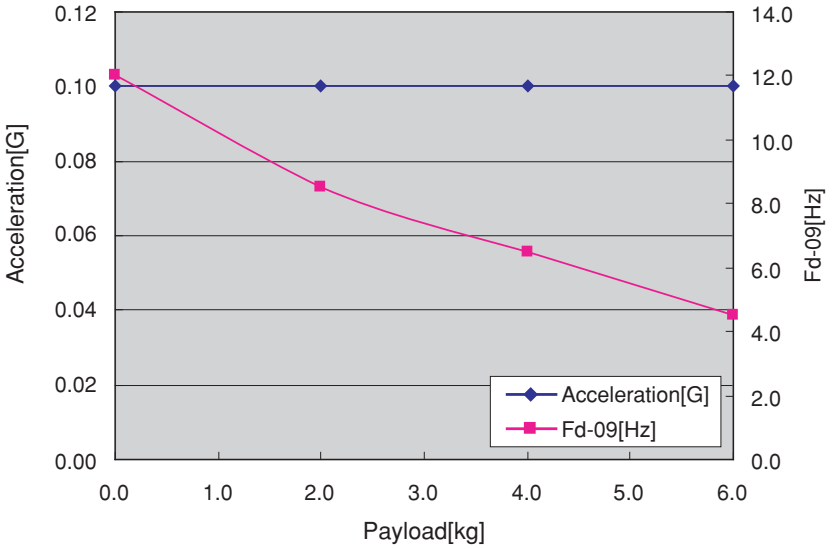
■ RDX

Model	T4H-2 (C4H-2)

Maximum payload [kg] 6.0 [kg]

Fd-00 Moment of inertia 0.029 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.10	12.0
2.0	0.10	8.5
4.0	0.10	6.5
6.0	0.10	4.5

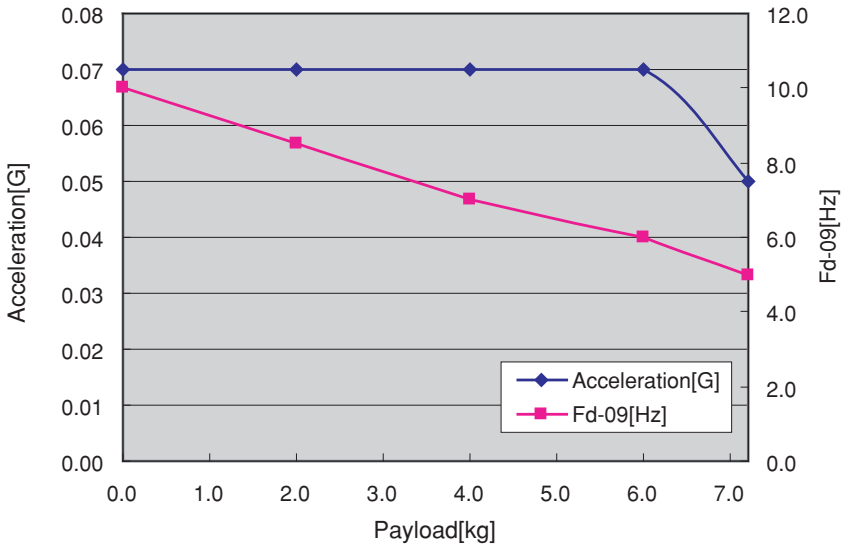


Model	T4H-2-BK (C4H-2-BK)

Maximum payload [kg] 7.2 [kg]

Fd-00 Moment of inertia 0.049 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.07	10.0
2.0	0.07	8.5
4.0	0.07	7.0
6.0	0.07	6.0
7.2	0.05	5.0

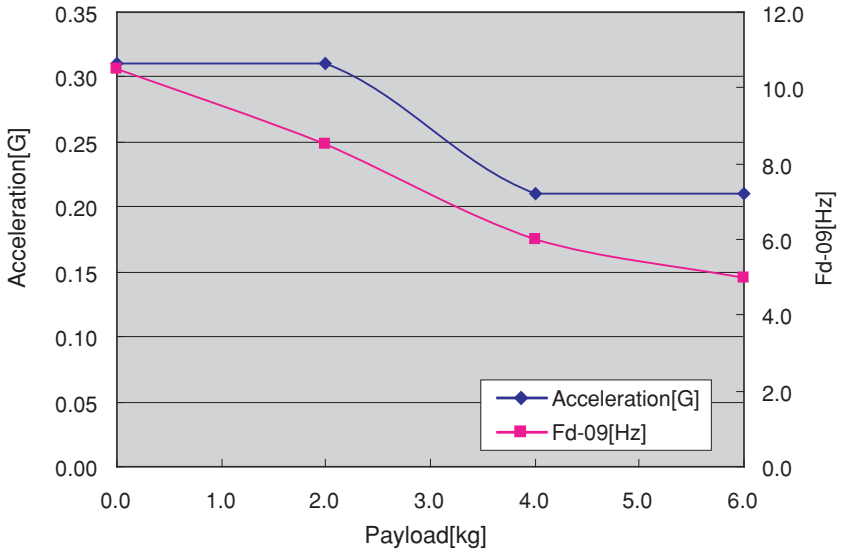


Model	T4H-6 (C4H-6)

Maximum payload [kg] 6.0 [kg]

Fd-00 Moment of inertia 0.044 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.31	10.5
2.0	0.31	8.5
4.0	0.21	6.0
6.0	0.21	5.0

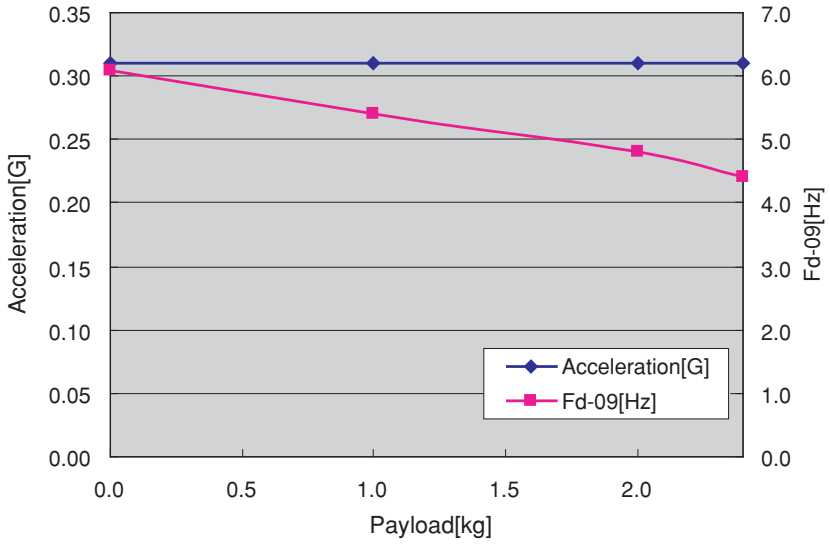


Model	T4H-6-BK (C4H-6-BK)

Maximum payload [kg] 2.4 [kg]

Fd-00 Moment of inertia 0.044 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 55.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.31	6.1
1.0	0.31	5.4
2.0	0.31	4.8
2.4	0.31	4.4

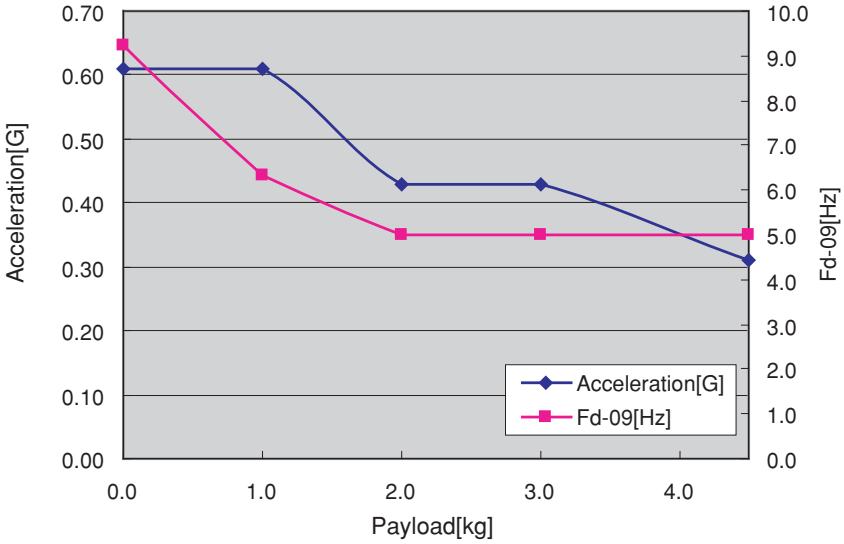


Model	T4H-12 (C4H-12)

Maximum payload [kg] 4.5 [kg]

Fd-00 Moment of inertia 0.038 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.61	9.2
1.0	0.61	6.4
2.0	0.43	5.0
3.0	0.43	5.0
4.5	0.31	5.0

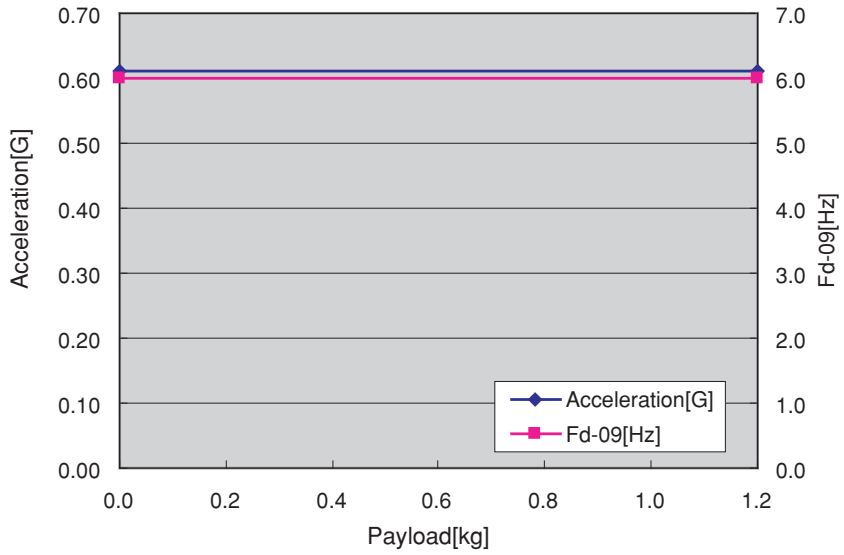


Model	T4H-12-BK (C4H-12-BK)

Maximum payload [kg] 1.2 [kg]

Fd-00 Moment of inertia 0.044 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.61	6.0
1.2	0.61	6.0

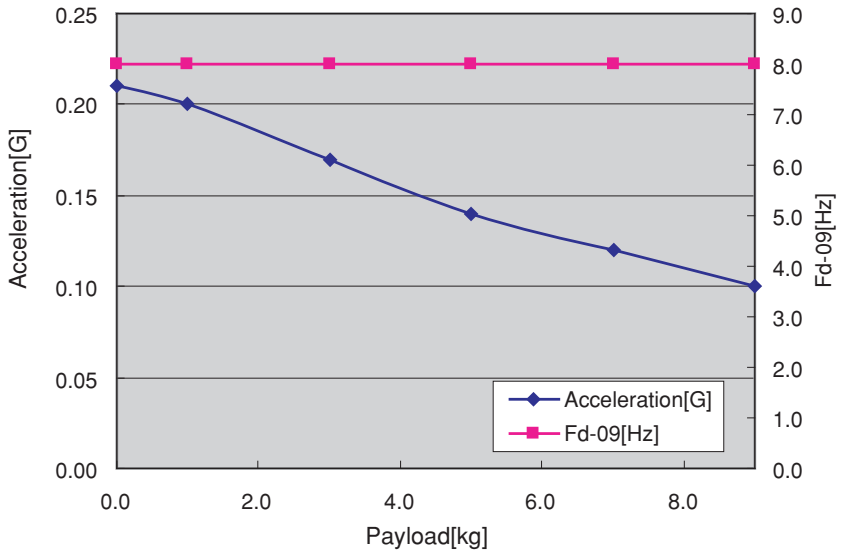


Model	T5H-6 (C5H-6)

Maximum payload [kg] 9.0 [kg]

Fd-00 Moment of inertia 0.063 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 85.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.21	8.0
1.0	0.20	8.0
3.0	0.17	8.0
5.0	0.14	8.0
7.0	0.12	8.0
9.0	0.10	8.0

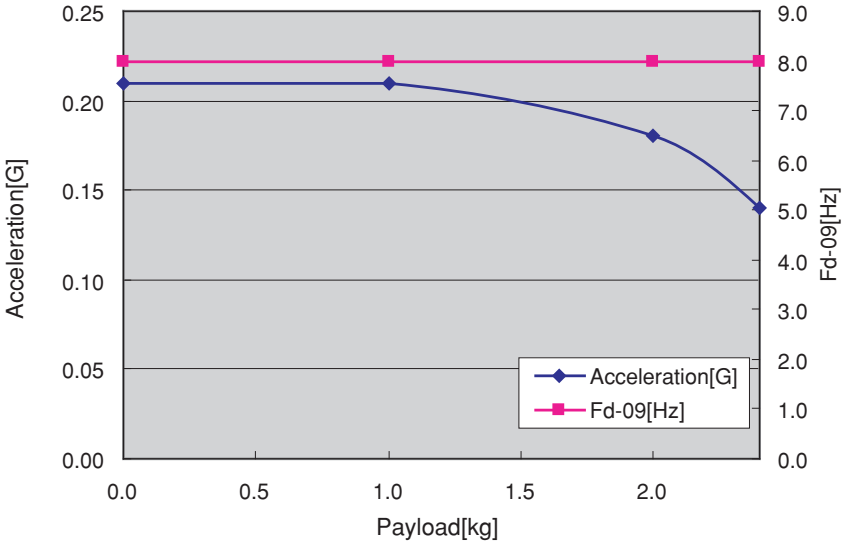


Model	T5H-6-BK (C5H-6-BK)

Maximum payload [kg] 2.4 [kg]

Fd-00 Moment of inertia 0.074 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.21	8.0
1.0	0.21	8.0
2.0	0.18	8.0
2.4	0.14	8.0

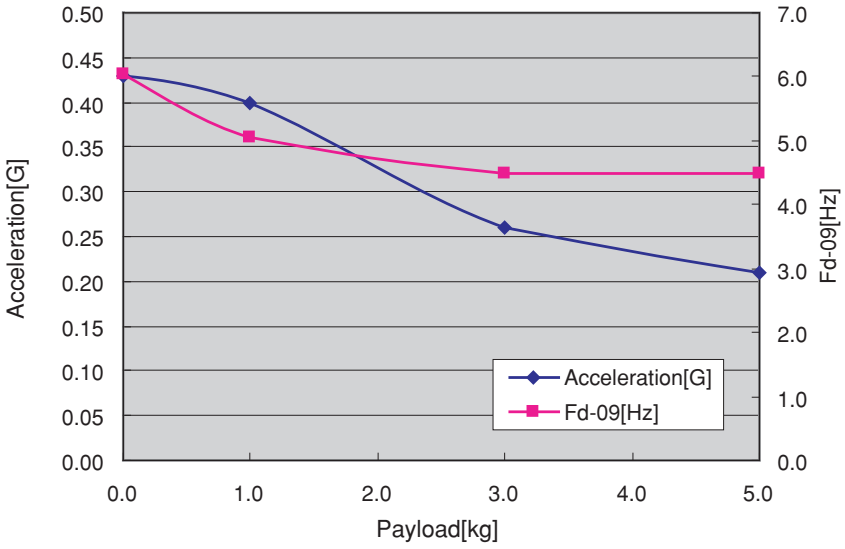


Model	T5H-12 (C5H-12)

Maximum payload [kg] 5.0 [kg]

Fd-00 Moment of inertia 0.067 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.43	6.0
1.0	0.40	5.1
3.0	0.26	4.5
5.0	0.21	4.5

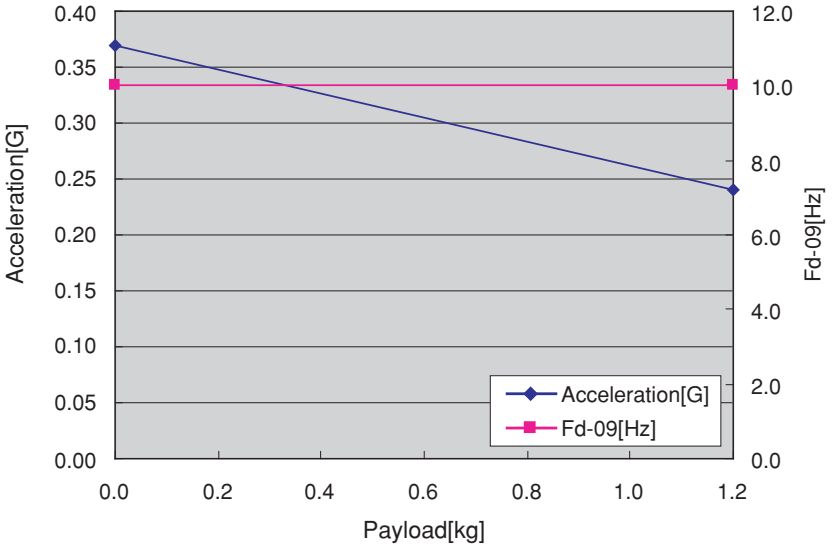


Model	T5H-12-BK (C5H-12-BK)

Maximum payload [kg] 1.2 [kg]

Fd-00 Moment of inertia 0.087 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.37	10.0
1.2	0.24	10.0

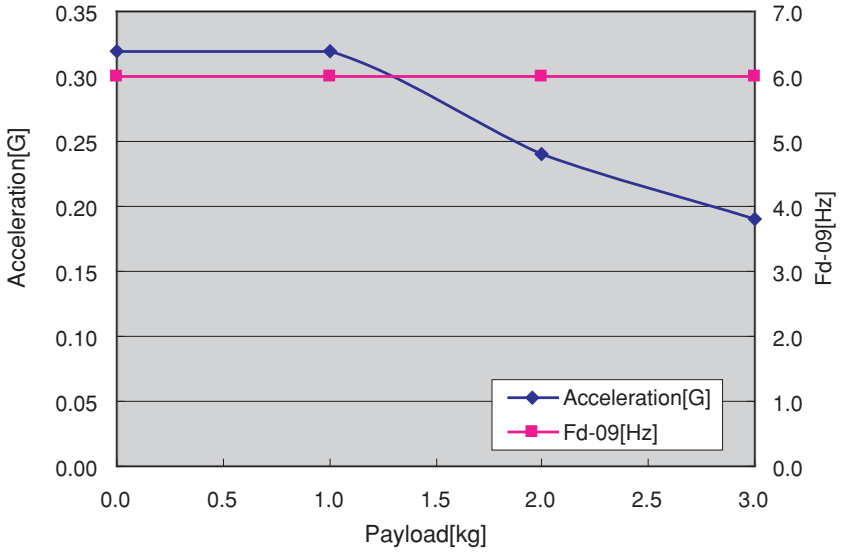


Model	T5H-20

Maximum payload [kg] 3.0 [kg]

Fd-00 Moment of inertia 0.100 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.32	6.0
1.0	0.32	6.0
2.0	0.24	6.0
3.0	0.19	6.0

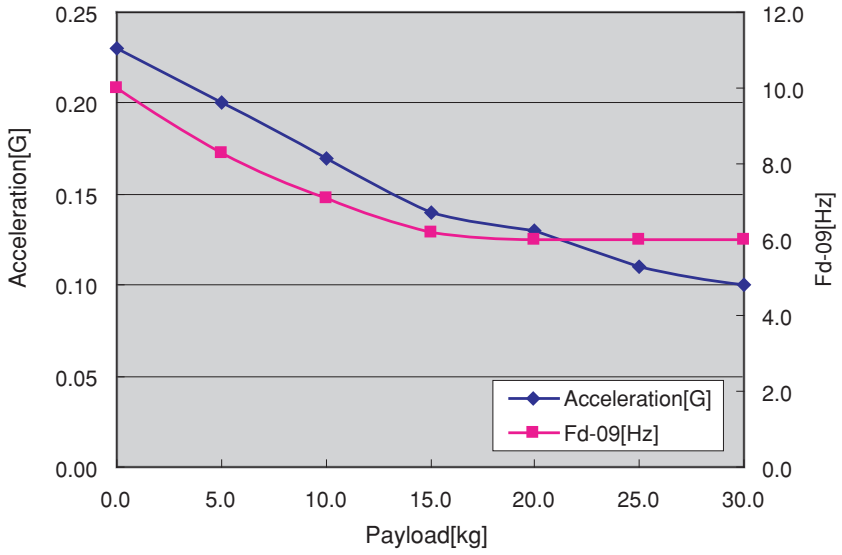


Model	T6-6 (C6-6)

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 0.092 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.23	10.0
5.0	0.20	8.3
10.0	0.17	7.1
15.0	0.14	6.2
20.0	0.13	6.0
25.0	0.11	6.0
30.0	0.10	6.0

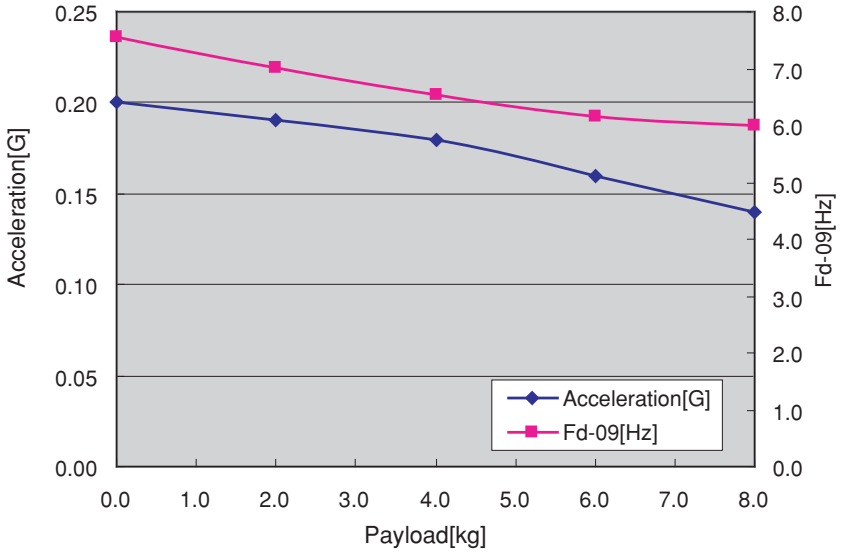


Model	T6-6-BK (C6-6-BK)

Maximum payload [kg] 8.0 [kg]

Fd-00 Moment of inertia 0.092 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.20	7.5
2.0	0.19	7.0
4.0	0.18	6.6
6.0	0.16	6.1
8.0	0.14	6.0

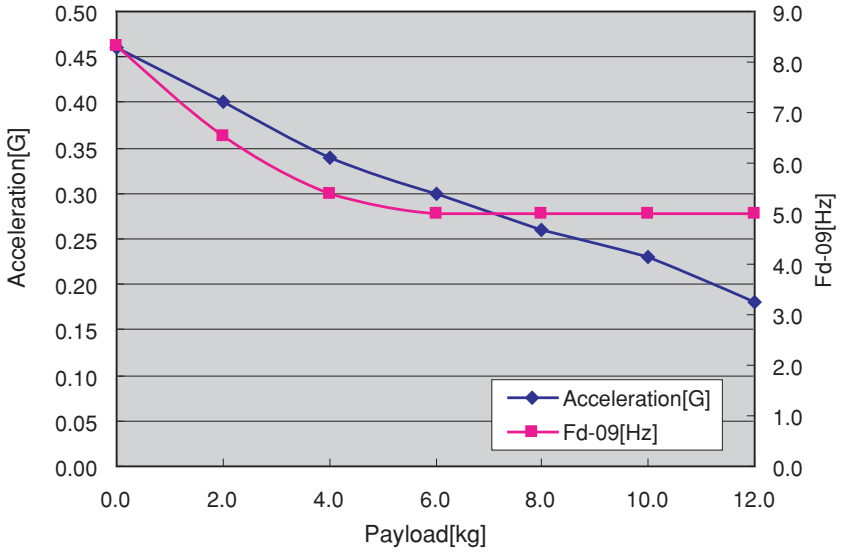


Model	T6-12 (C6-12)

Maximum payload [kg] 12.0 [kg]

Fd-00 Moment of inertia 0.110 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.46	8.3
2.0	0.40	6.5
4.0	0.34	5.4
6.0	0.30	5.0
8.0	0.26	5.0
10.0	0.23	5.0
12.0	0.18	5.0

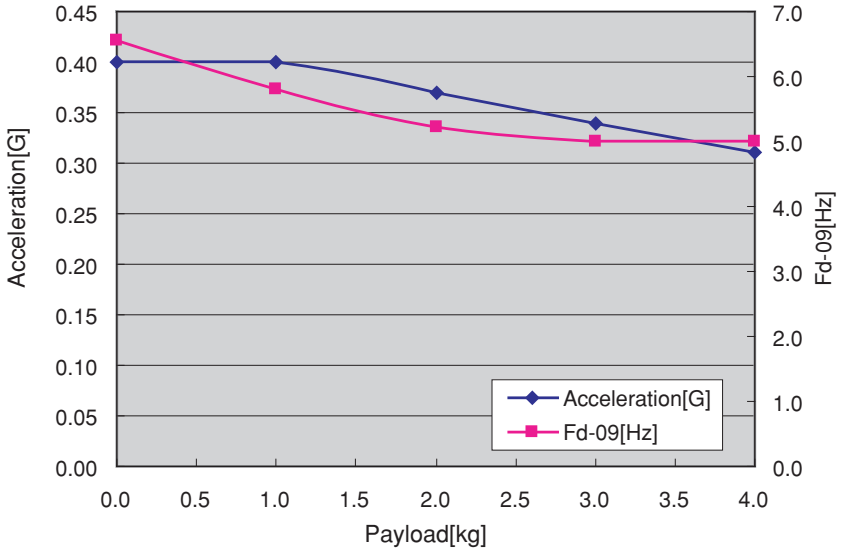


Model	T6-12-BK (C6-12-BK)

Maximum payload [kg] 4.0 [kg]

Fd-00 Moment of inertia 0.110 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.40	6.6
1.0	0.40	5.8
2.0	0.37	5.2
3.0	0.34	5.0
4.0	0.31	5.0

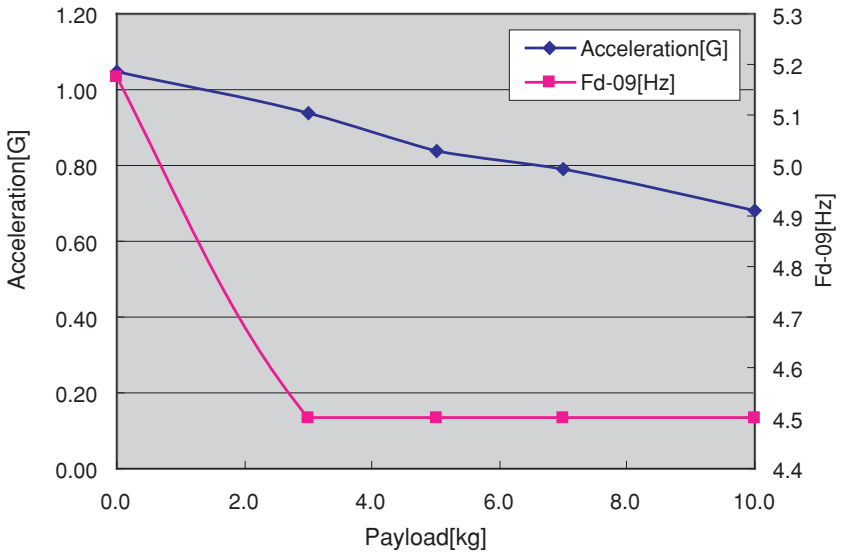


Model	T6-20

Maximum payload [kg] 10.0 [kg]

Fd-00 Moment of inertia 0.110 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 45.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.05	5.2
3.0	0.94	4.5
5.0	0.84	4.5
7.0	0.79	4.5
10.0	0.68	4.5

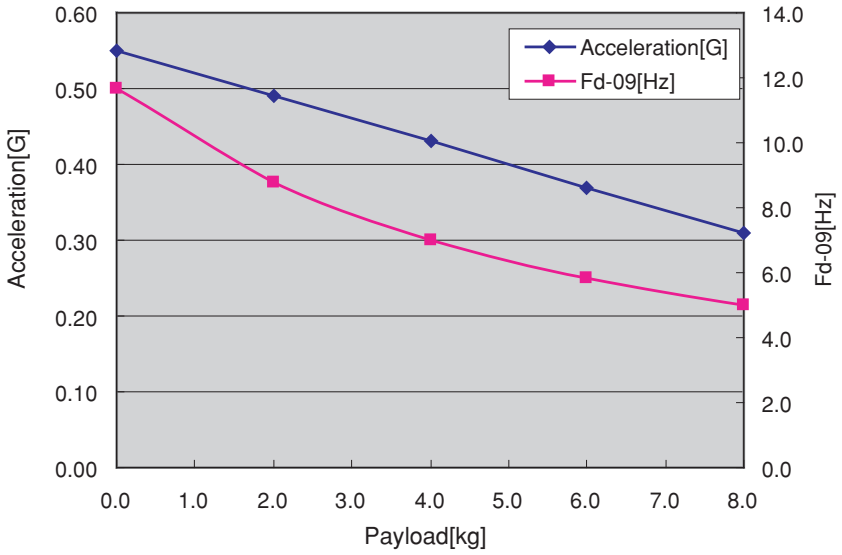


Model	T7-12

Maximum payload [kg] 8.0 [kg]

Fd-00 Moment of inertia 0.125 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.55	11.6
2.0	0.49	8.8
4.0	0.43	7.0
6.0	0.37	5.9
8.0	0.31	5.0

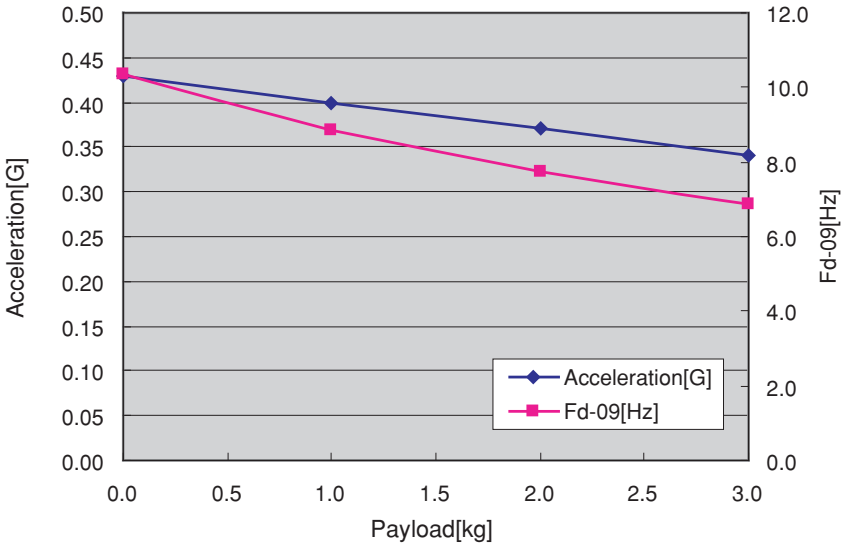


Model	T7-12-BK

Maximum payload [kg] 3.0 [kg]

Fd-00 Moment of inertia 0.134 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.43	10.4
1.0	0.40	8.9
2.0	0.37	7.7
3.0	0.34	6.9

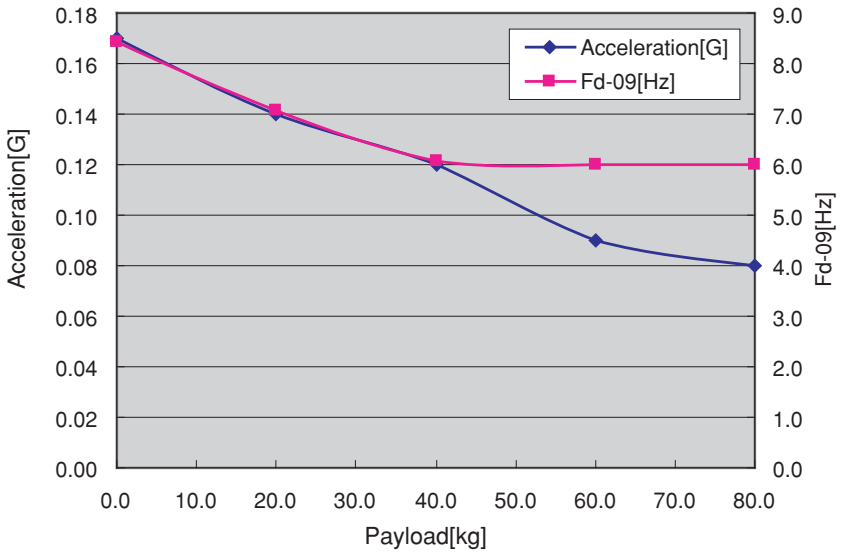


Model	T9-5

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 0.282 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.17	8.4
20.0	0.14	7.1
40.0	0.12	6.1
60.0	0.09	6.0
80.0	0.08	6.0

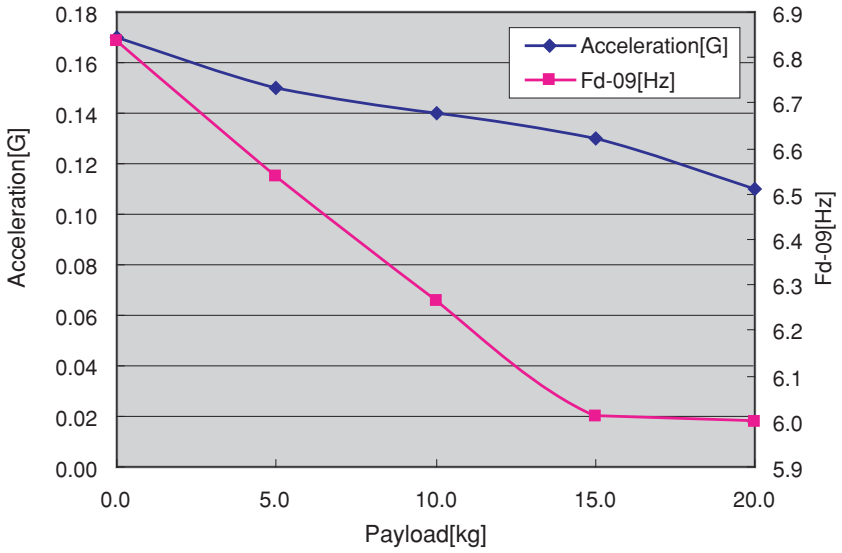


Model	T9-5-BK

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.282 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.17	6.8
5.0	0.15	6.5
10.0	0.14	6.3
15.0	0.13	6.0
20.0	0.11	6.0

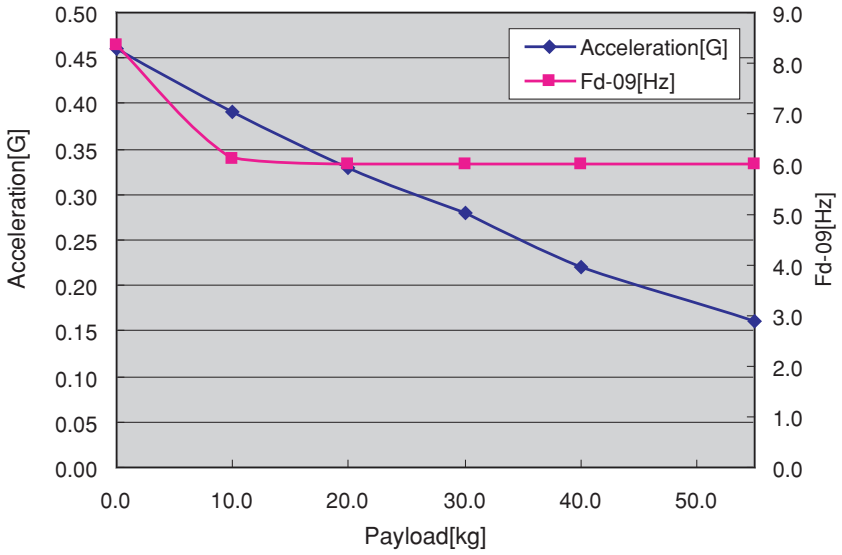


Model	T9-10

Maximum payload [kg] 55.0 [kg]

Fd-00 Moment of inertia 0.304 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.46	8.3
10.0	0.39	6.1
20.0	0.33	6.0
30.0	0.28	6.0
40.0	0.22	6.0
55.0	0.16	6.0

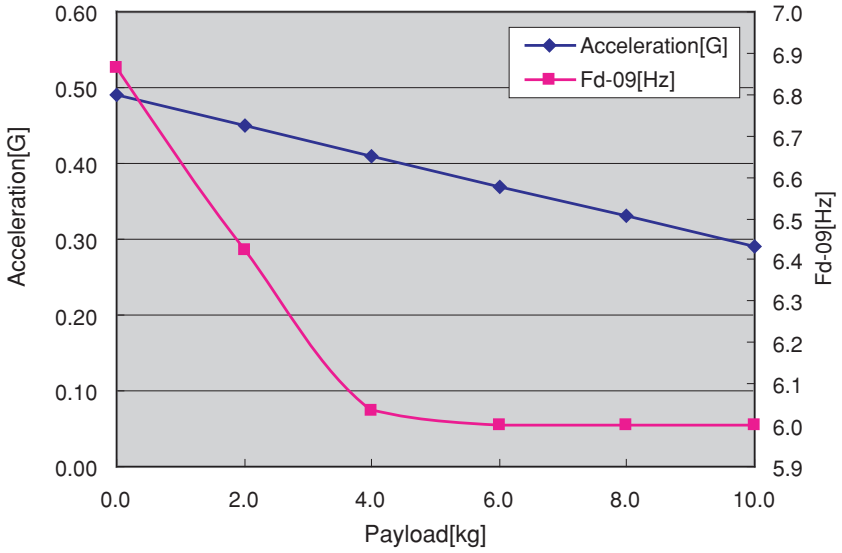


Model	T9-10-BK

Maximum payload [kg] 10.0 [kg]

Fd-00 Moment of inertia 0.304 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.49	6.9
2.0	0.45	6.4
4.0	0.41	6.0
6.0	0.37	6.0
8.0	0.33	6.0
10.0	0.29	6.0

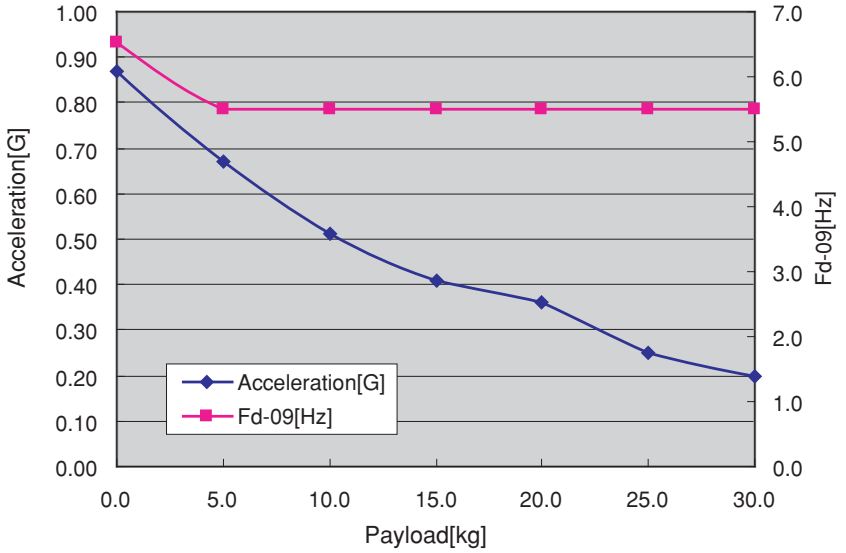


Model	T9-20

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 0.399 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.87	6.5
5.0	0.67	5.5
10.0	0.51	5.5
15.0	0.41	5.5
20.0	0.36	5.5
25.0	0.25	5.5
30.0	0.20	5.5

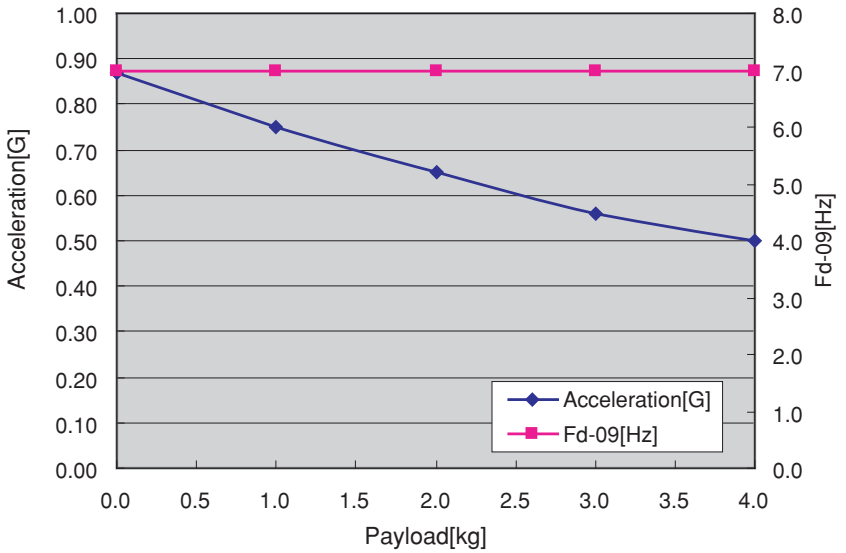


Model	T9-20-BK

Maximum payload [kg] 4.0 [kg]

Fd-00 Moment of inertia 0.399 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.87	7.0
1.0	0.75	7.0
2.0	0.65	7.0
3.0	0.56	7.0
4.0	0.50	7.0

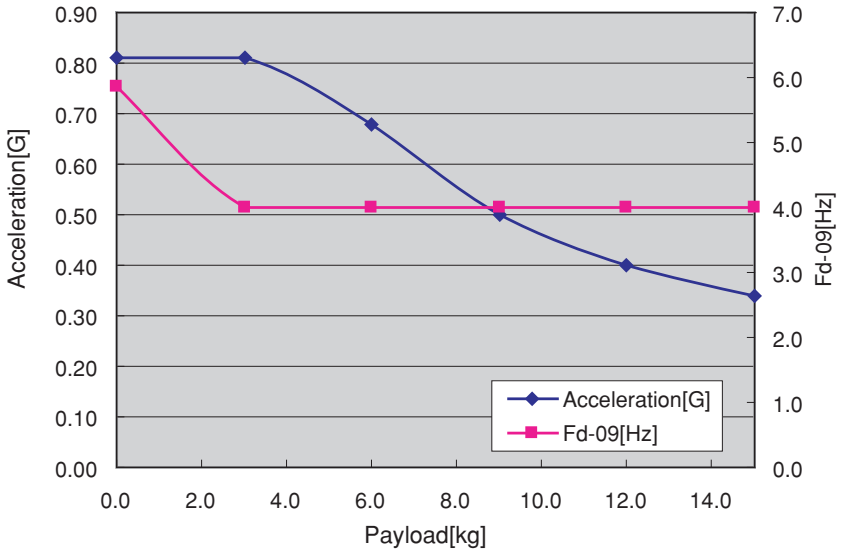


Model	T9-30

Maximum payload [kg] 15.0 [kg]

Fd-00 Moment of inertia 0.501 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 90.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.81	5.9
3.0	0.81	4.0
6.0	0.68	4.0
9.0	0.50	4.0
12.0	0.40	4.0
15.0	0.34	4.0

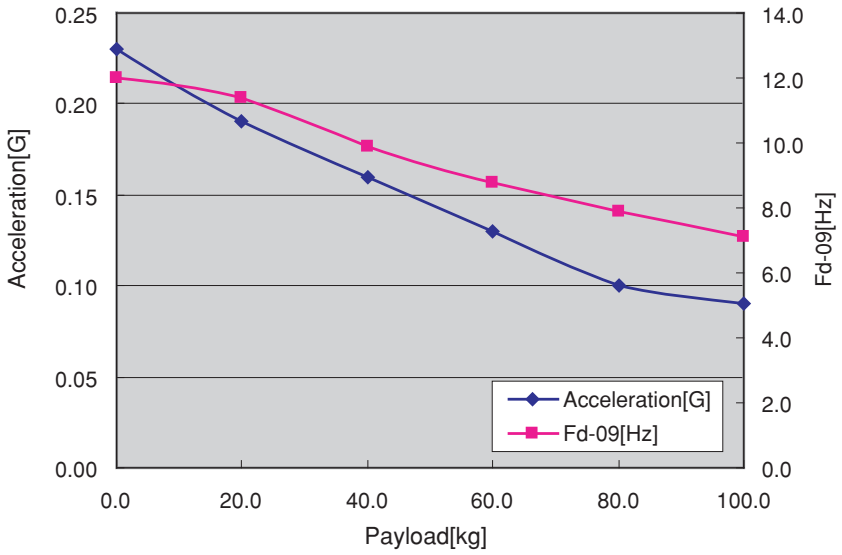


Model	T9H-5

Maximum payload [kg] 100.0 [kg]

Fd-00 Moment of inertia 0.600 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 50.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.23	12.0
20.0	0.19	11.4
40.0	0.16	9.9
60.0	0.13	8.8
80.0	0.10	7.9
100.0	0.09	7.1

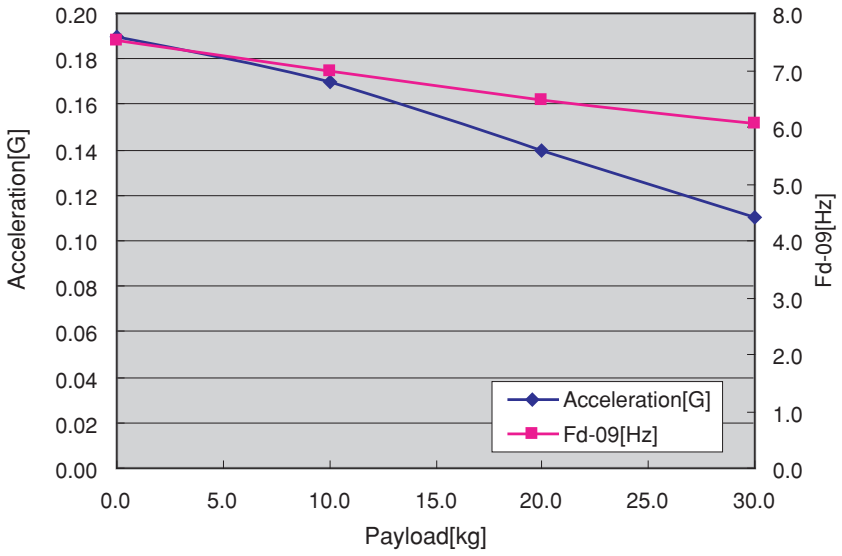


Model	T9H-5-BK

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 0.416 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.19	7.5
10.0	0.17	7.0
20.0	0.14	6.5
30.0	0.11	6.1

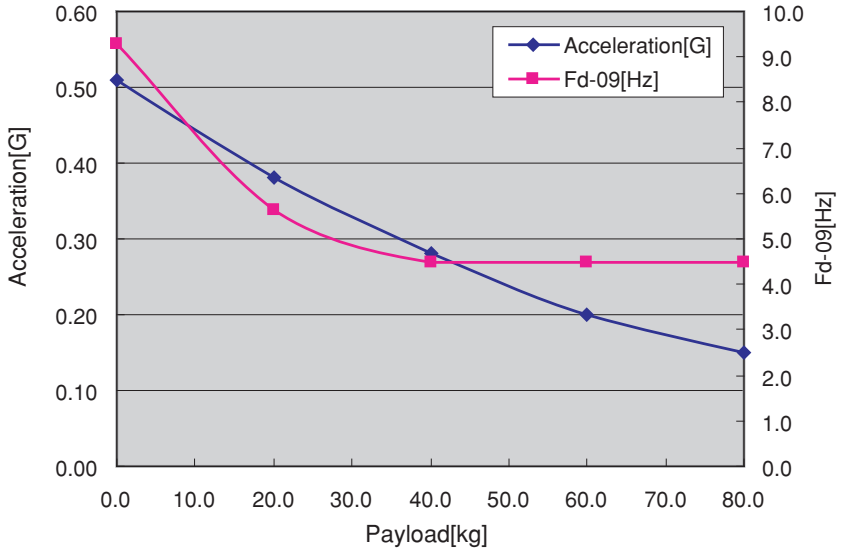


Model	T9H-10

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 0.424 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.51	9.3
20.0	0.38	5.6
40.0	0.28	4.5
60.0	0.20	4.5
80.0	0.15	4.5

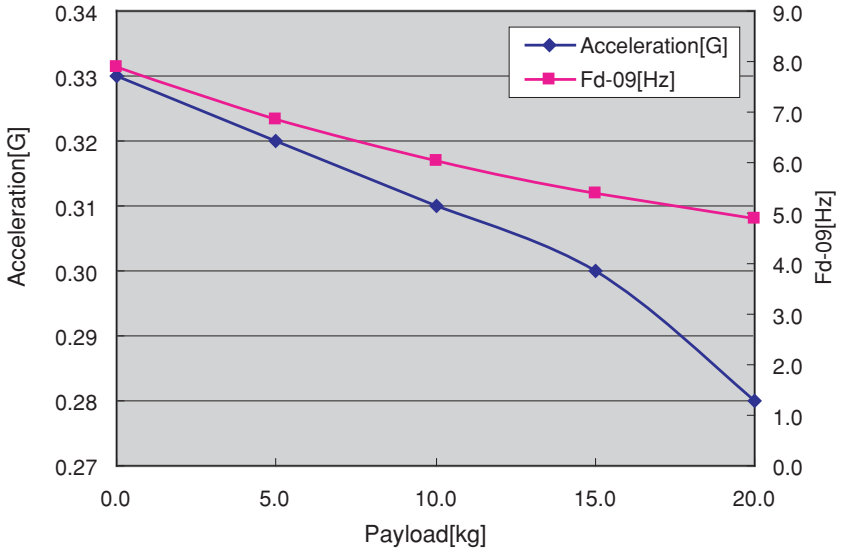


Model	T9H-10-BK

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.424 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.33	7.9
5.0	0.32	6.8
10.0	0.31	6.0
15.0	0.30	5.4
20.0	0.28	4.9

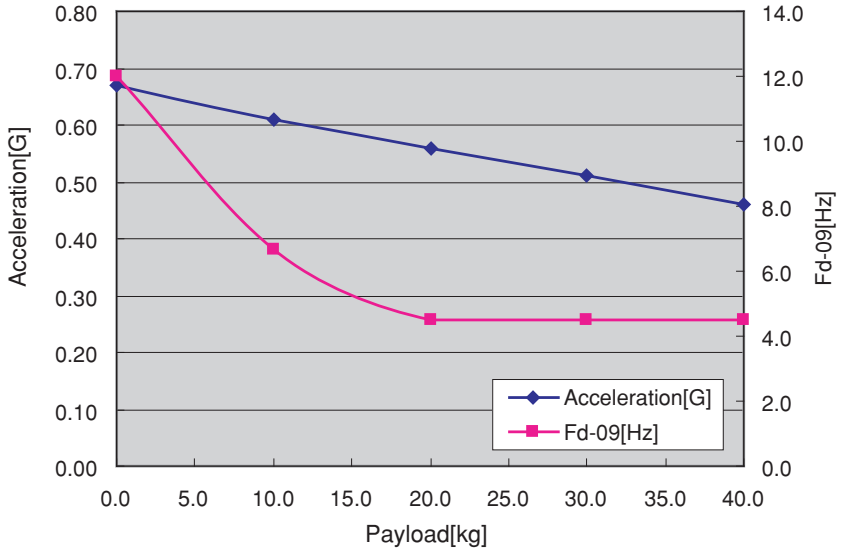


Model	T9H-20

Maximum payload [kg] 40.0 [kg]

Fd-00 Moment of inertia 0.926 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 40.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.67	12.0
10.0	0.61	6.7
20.0	0.56	4.5
30.0	0.51	4.5
40.0	0.46	4.5

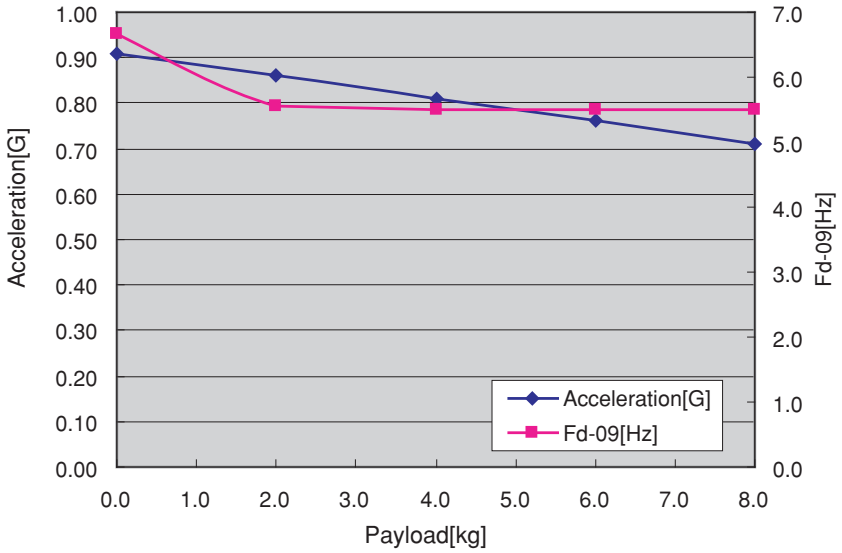


Model	T9H-20-BK

Maximum payload [kg] 8.0 [kg]

Fd-00 Moment of inertia 0.564 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 60.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.91	6.7
2.0	0.86	5.6
4.0	0.81	5.5
6.0	0.76	5.5
8.0	0.71	5.5

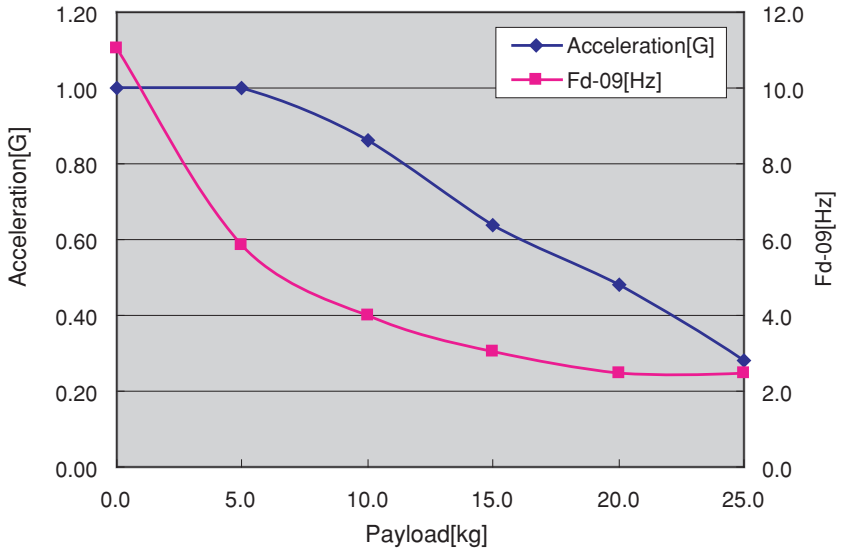


Model	T9H-30

Maximum payload [kg] 25.0 [kg]

Fd-00 Moment of inertia 0.715 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.00	11.1
5.0	1.00	5.9
10.0	0.86	4.0
15.0	0.64	3.0
20.0	0.48	2.5
25.0	0.28	2.5

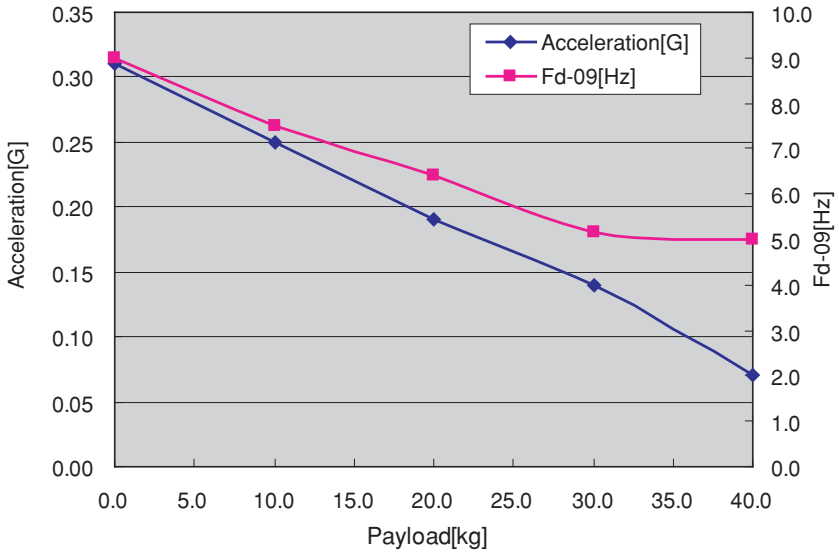


Model	F8-6 (C8-6)

Maximum payload [kg] 40.0 [kg]

Fd-00 Moment of inertia 0.109 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 80.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.31	9.0
10.0	0.25	7.5
20.0	0.19	6.4
30.0	0.14	5.2
40.0	0.07	5.0

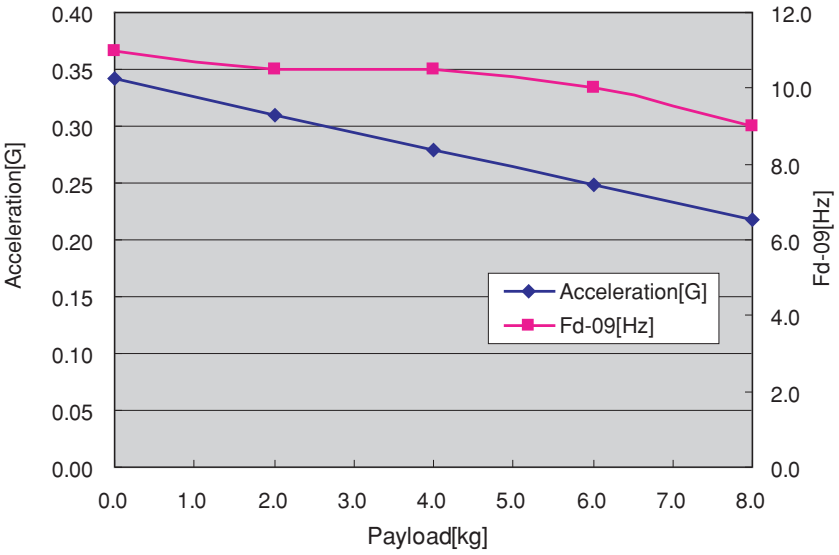


Model	F8-6-BK (C8-6-BK)

Maximum payload [kg] 8.0 [kg]

Fd-00 Moment of inertia 0.154 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.34	11.0
2.0	0.31	10.5
4.0	0.28	10.5
6.0	0.25	10.0
8.0	0.22	9.0

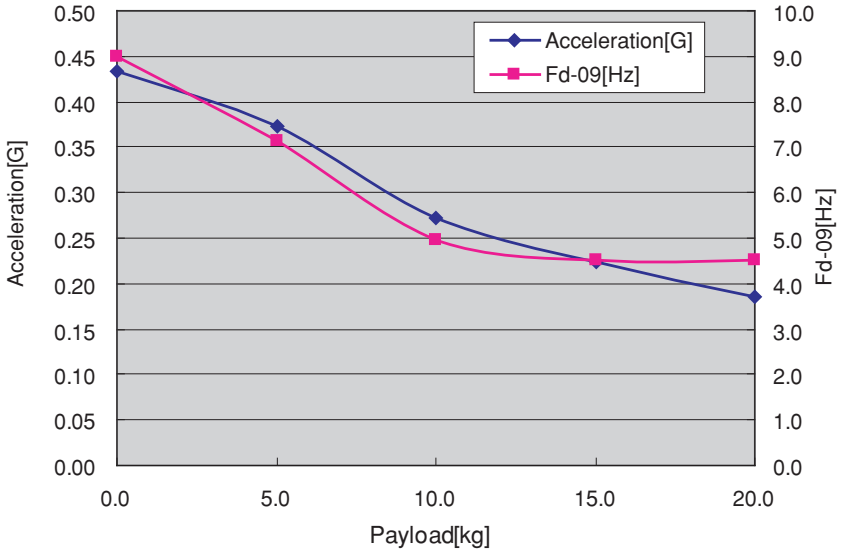


Model	F8-12 (C8-12)

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.124 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 80.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.43	9.0
5.0	0.37	7.2
10.0	0.27	5.0
15.0	0.22	4.5
20.0	0.19	4.5

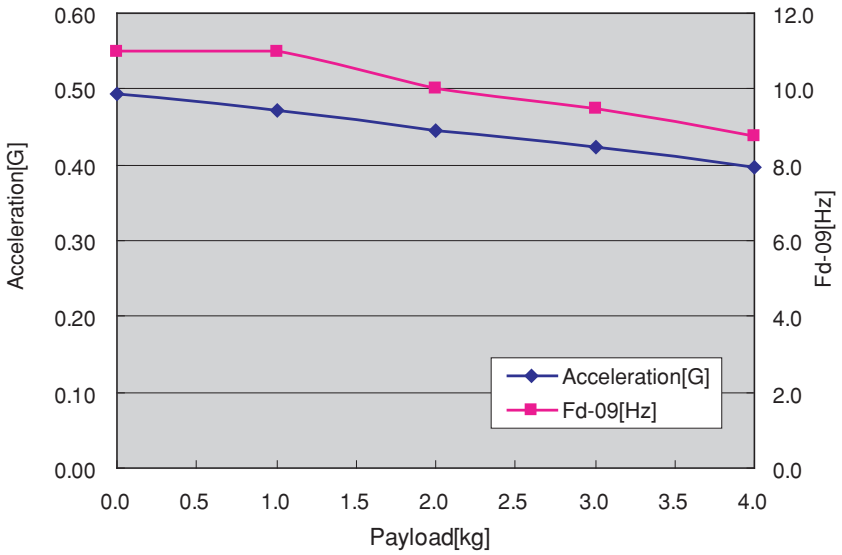


Model	F8-12-BK (C8-12-BK)

Maximum payload [kg] 4.0 [kg]

Fd-00 Moment of inertia 0.169 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.49	11.0
1.0	0.47	11.0
2.0	0.45	10.0
3.0	0.42	9.5
4.0	0.40	8.8

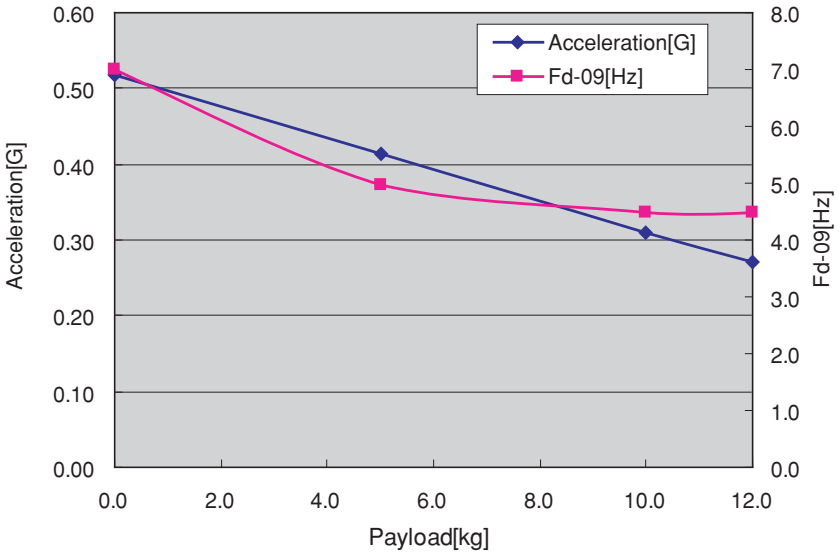


Model	F8-20 (C8-20)

Maximum payload [kg] 12.0 [kg]

Fd-00 Moment of inertia 0.160 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 130.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.52	7.0
5.0	0.41	5.0
10.0	0.31	4.5
12.0	0.27	4.5

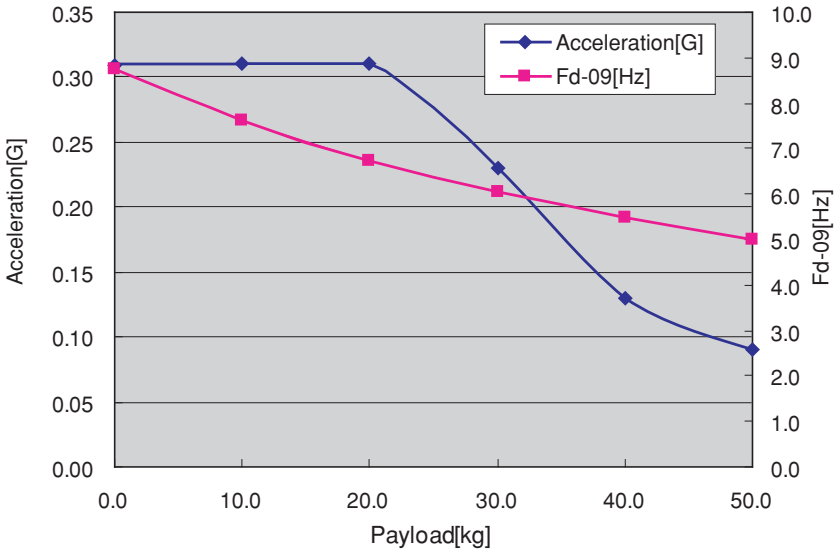


Model	F8L-5 (C8L-5)

Maximum payload [kg] 50.0 [kg]

Fd-00 Moment of inertia 0.168 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 80.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.31	8.7
10.0	0.31	7.6
20.0	0.31	6.7
30.0	0.23	6.0
40.0	0.13	5.5
50.0	0.09	5.0

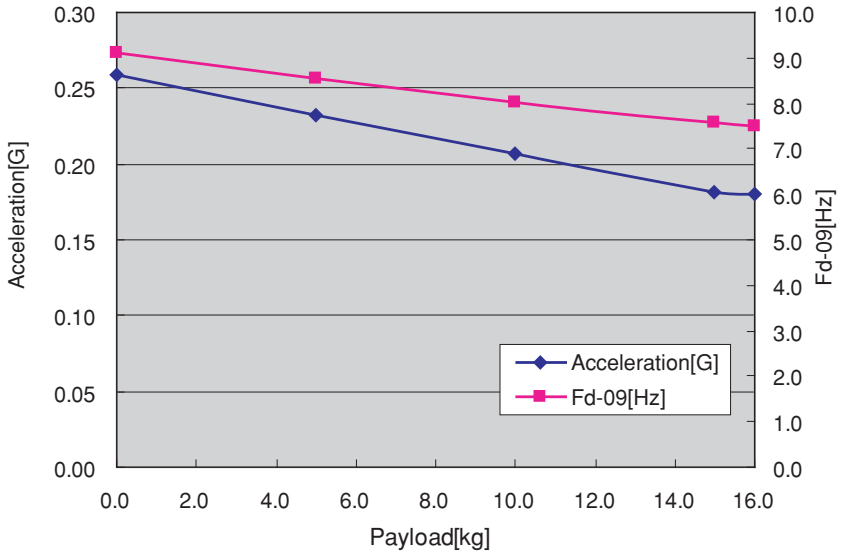


Model	F8L-5-BK (C8L-5-BK)

Maximum payload [kg] 16.0 [kg]

Fd-00 Moment of inertia 0.213 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.26	9.1
5.0	0.23	8.5
10.0	0.21	8.0
15.0	0.18	7.6
16.0	0.18	7.5

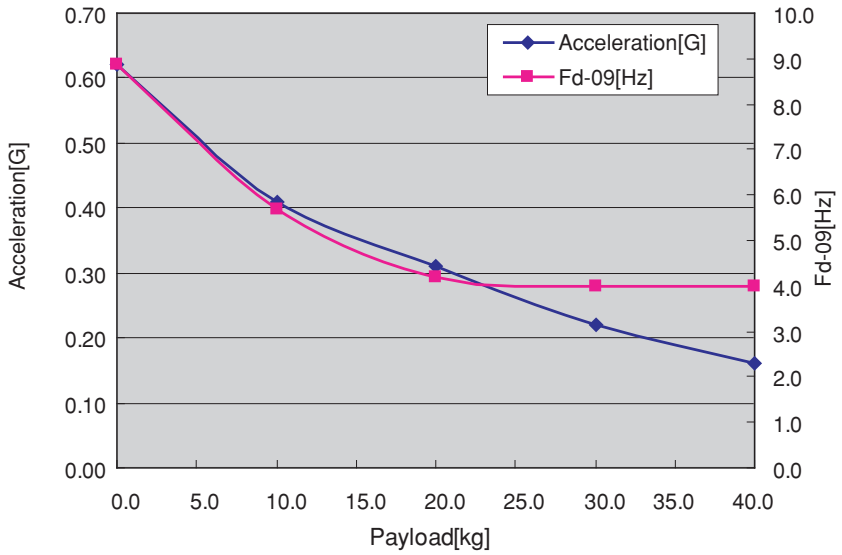


Model	F8L-10 (C8L-10)

Maximum payload [kg] 40.0 [kg]

Fd-00 Moment of inertia 0.184 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.62	8.9
10.0	0.41	5.7
20.0	0.31	4.2
30.0	0.22	4.0
40.0	0.16	4.0

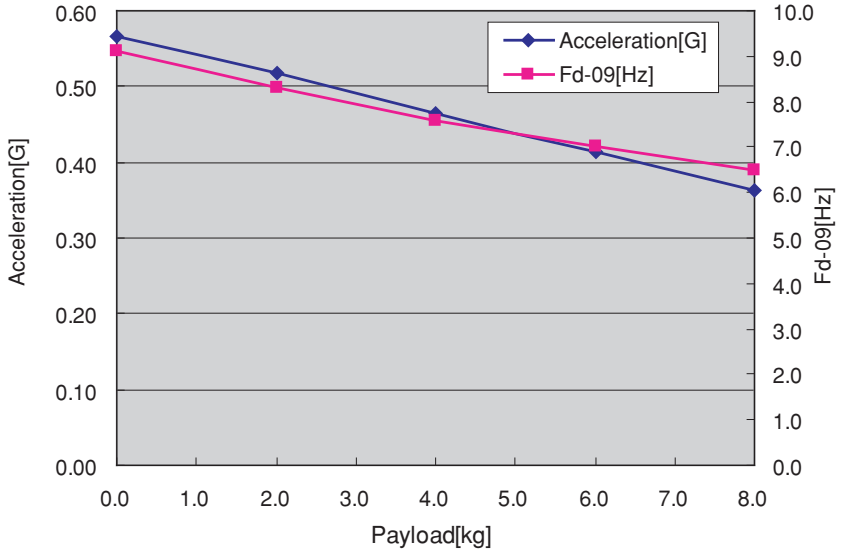


Model	F8L-10-BK (C8L-10-BK)

Maximum payload [kg] 8.0 [kg]

Fd-00 Moment of inertia 0.229 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.57	9.1
2.0	0.52	8.3
4.0	0.46	7.6
6.0	0.41	7.0
8.0	0.36	6.5

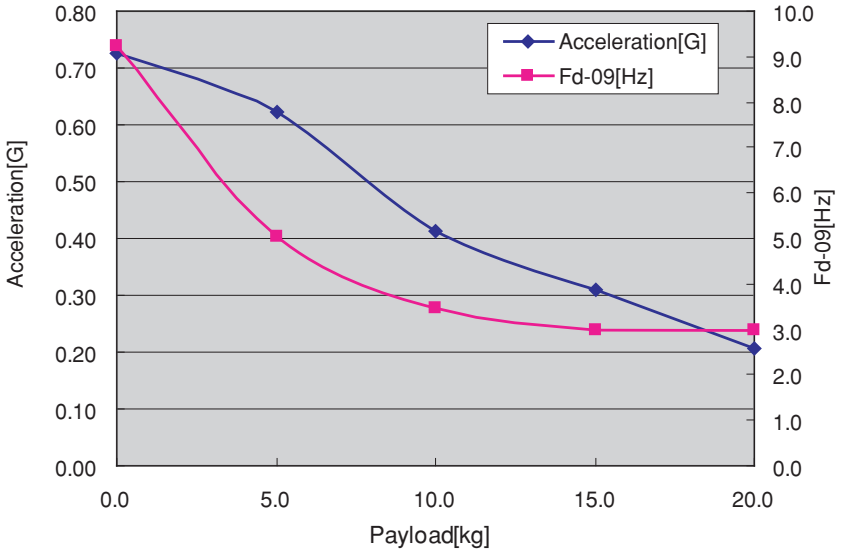


Model	F8L-20 (C8L-20)

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.254 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 80.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.72	9.2
5.0	0.62	5.0
10.0	0.41	3.5
15.0	0.31	3.0
20.0	0.21	3.0

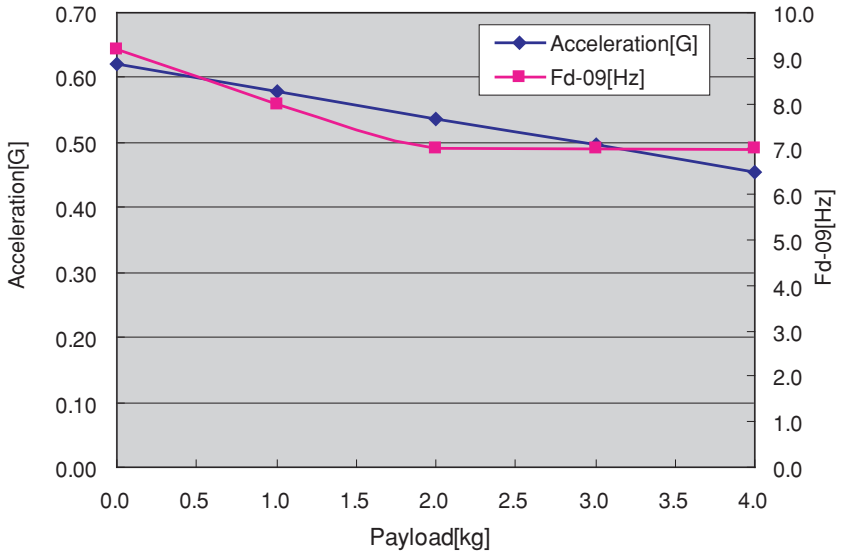


Model	F8L-20-BK (C8L-20-BK)

Maximum payload [kg] 4.0 [kg]

Fd-00 Moment of inertia 0.299 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.62	9.2
1.0	0.58	8.0
2.0	0.54	7.0
3.0	0.50	7.0
4.0	0.46	7.0

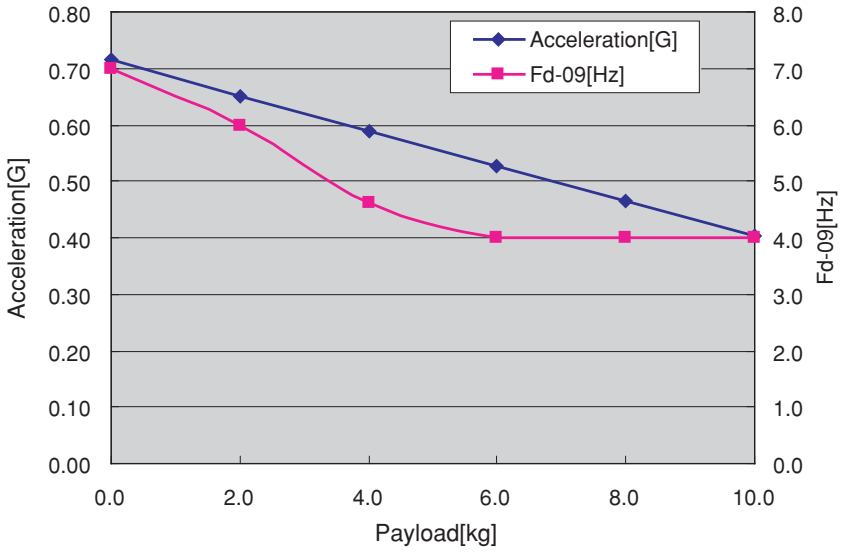


Model	F8L-30

Maximum payload [kg] 10.0 [kg]

Fd-00 Moment of inertia 0.368 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 80.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.71	7.0
2.0	0.65	6.0
4.0	0.59	4.6
6.0	0.53	4.0
8.0	0.47	4.0
10.0	0.40	4.0

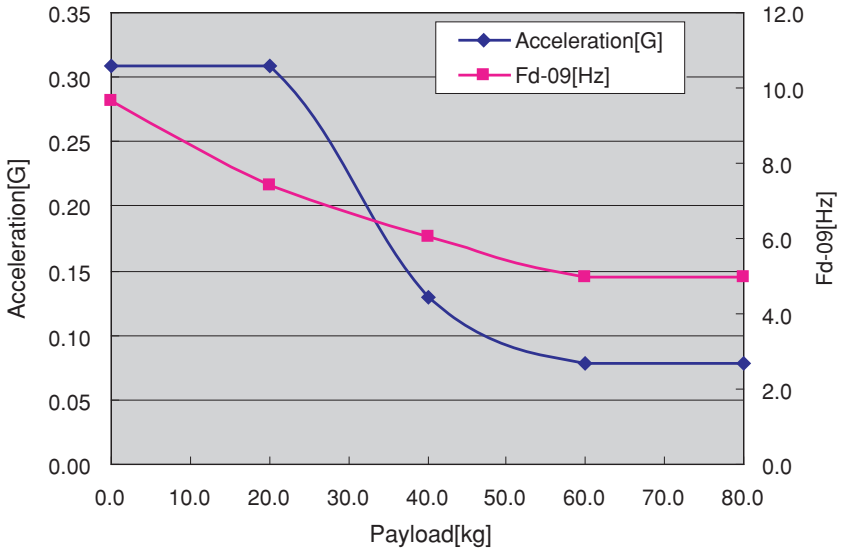


Model	F8LH-5 (C8LH-5)

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 0.171 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.31	9.7
20.0	0.31	7.4
40.0	0.13	6.0
60.0	0.08	5.0
80.0	0.08	5.0

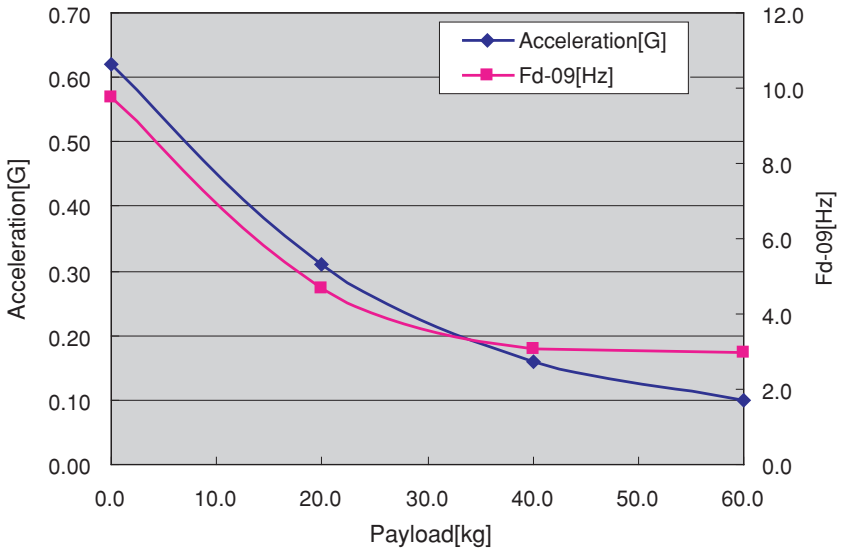


Model	F8LH-10 (C8LH-10)

Maximum payload [kg] 60.0 [kg]

Fd-00 Moment of inertia 0.193 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.62	9.8
20.0	0.31	4.7
40.0	0.16	3.1
60.0	0.10	3.0

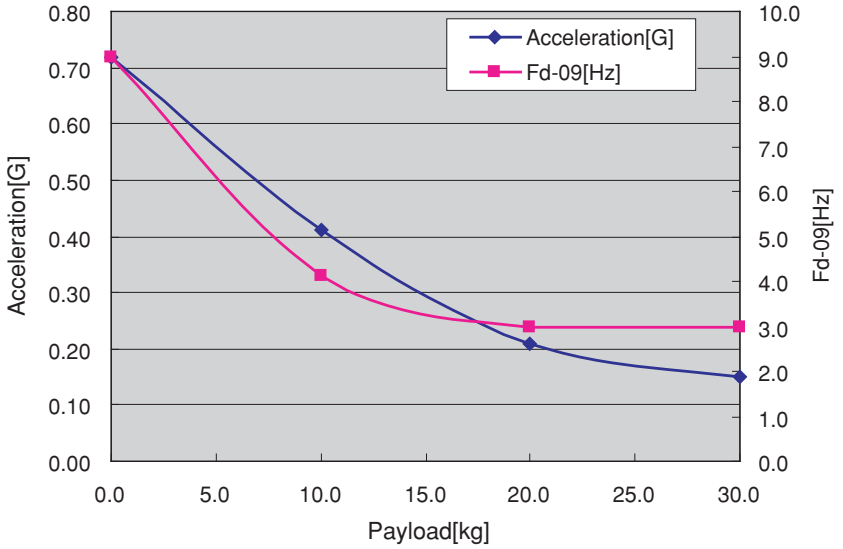


Model	F8LH-20 (C8LH-20)

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 0.292 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.72	9.0
10.0	0.41	4.1
20.0	0.21	3.0
30.0	0.15	3.0

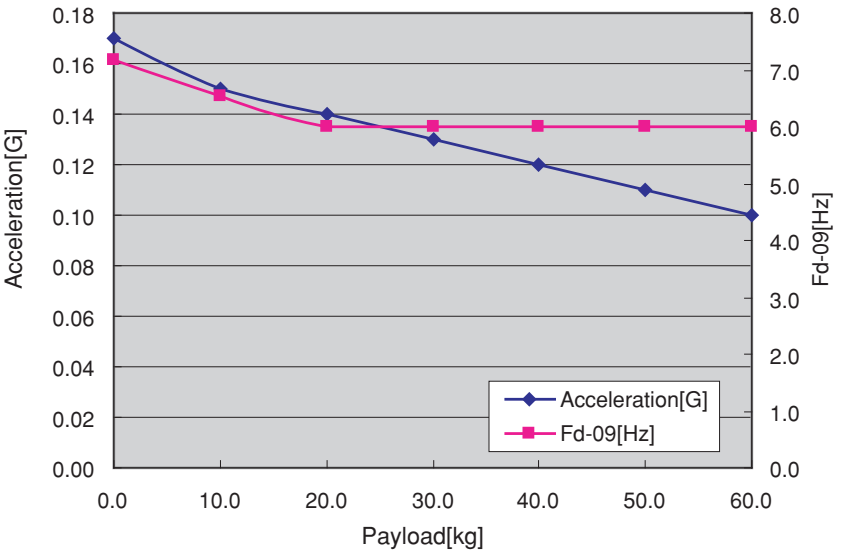


Model	F10-5 (C10-5)

Maximum payload [kg] 60.0 [kg]

Fd-00 Moment of inertia 0.289 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.17	7.2
10.0	0.15	6.5
20.0	0.14	6.0
30.0	0.13	6.0
40.0	0.12	6.0
50.0	0.11	6.0
60.0	0.10	6.0

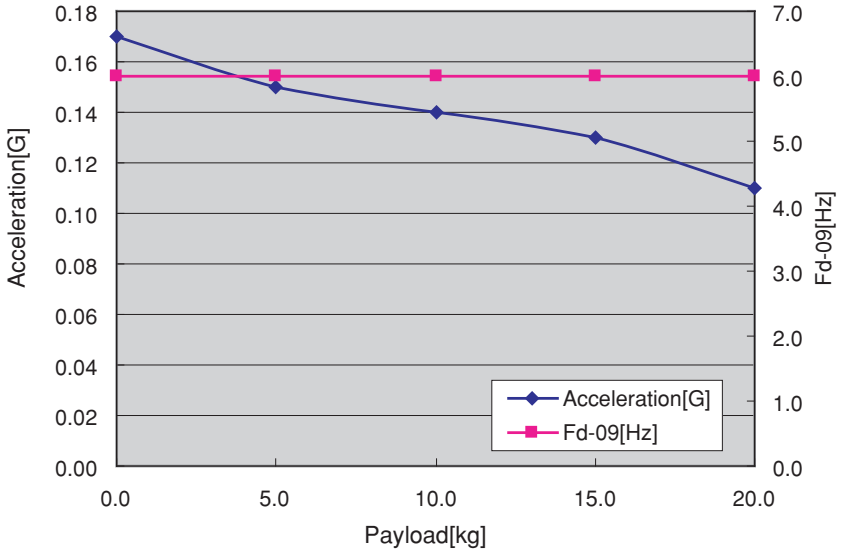


Model	F10-5-BK (C10-5-BK)

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.289 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.17	6.0
5.0	0.15	6.0
10.0	0.14	6.0
15.0	0.13	6.0
20.0	0.11	6.0

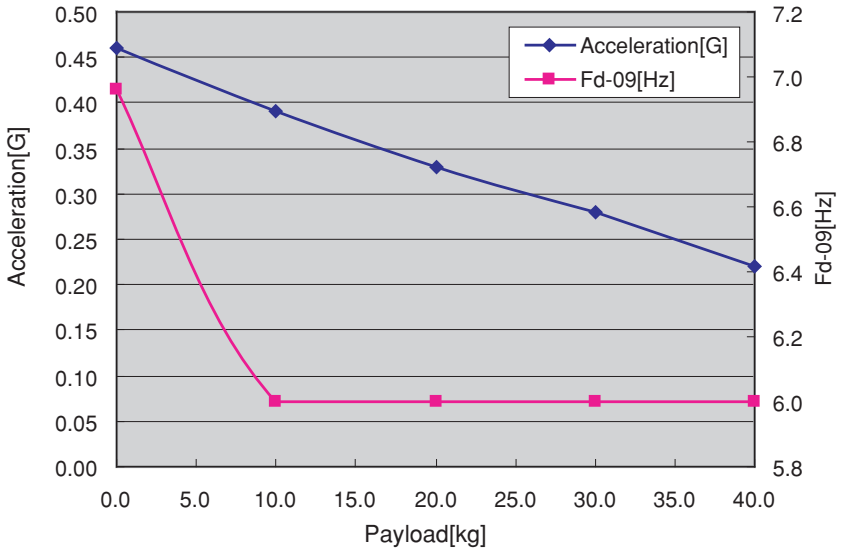


Model	F10-10 (C10-10)

Maximum payload [kg] 40.0 [kg]

Fd-00 Moment of inertia 0.304 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.46	7.0
10.0	0.39	6.0
20.0	0.33	6.0
30.0	0.28	6.0
40.0	0.22	6.0

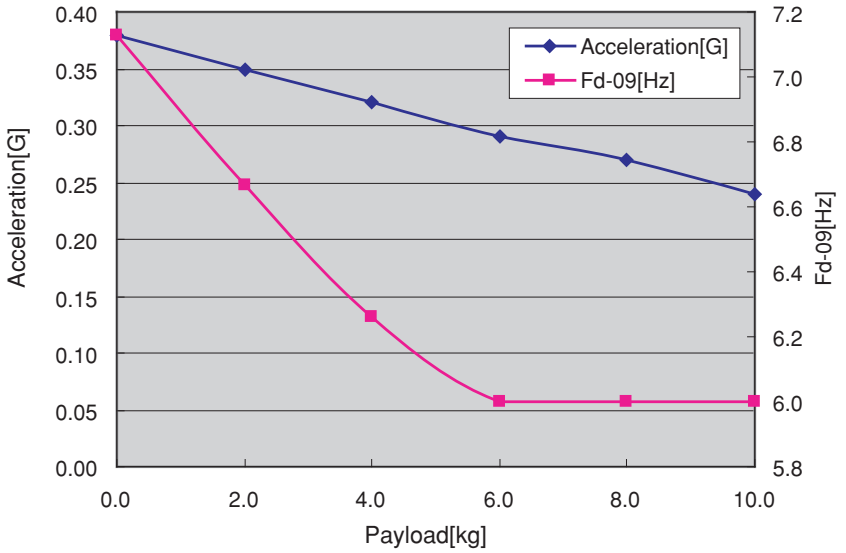


Model	F10-10-BK (C10-10-BK)

Maximum payload [kg] 10.0 [kg]

Fd-00 Moment of inertia 0.304 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.38	7.1
2.0	0.35	6.7
4.0	0.32	6.3
6.0	0.29	6.0
8.0	0.27	6.0
10.0	0.24	6.0

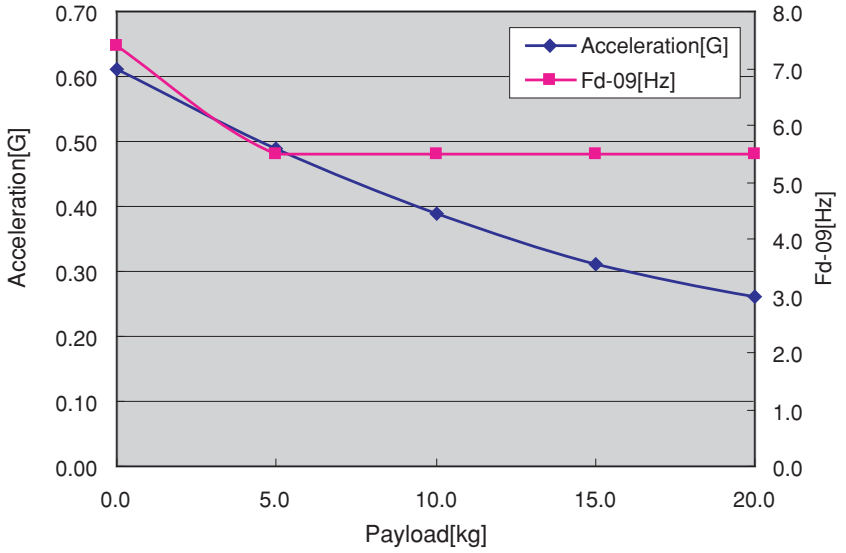


Model	F10-20 (C10-20)

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.399 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.61	7.4
5.0	0.49	5.5
10.0	0.39	5.5
15.0	0.31	5.5
20.0	0.26	5.5

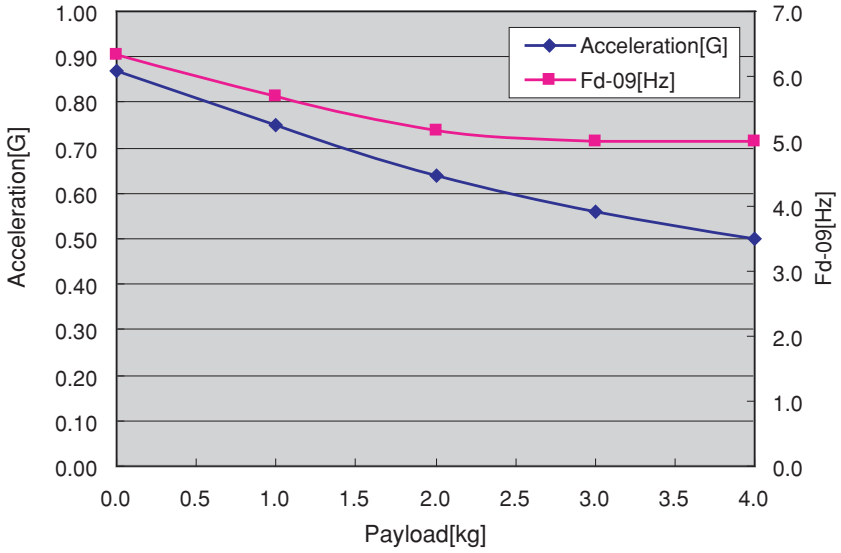


Model	F10-20-BK (C10-20-BK)

Maximum payload [kg] 4.0 [kg]

Fd-00 Moment of inertia 0.399 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.87	6.3
1.0	0.75	5.7
2.0	0.64	5.2
3.0	0.56	5.0
4.0	0.50	5.0

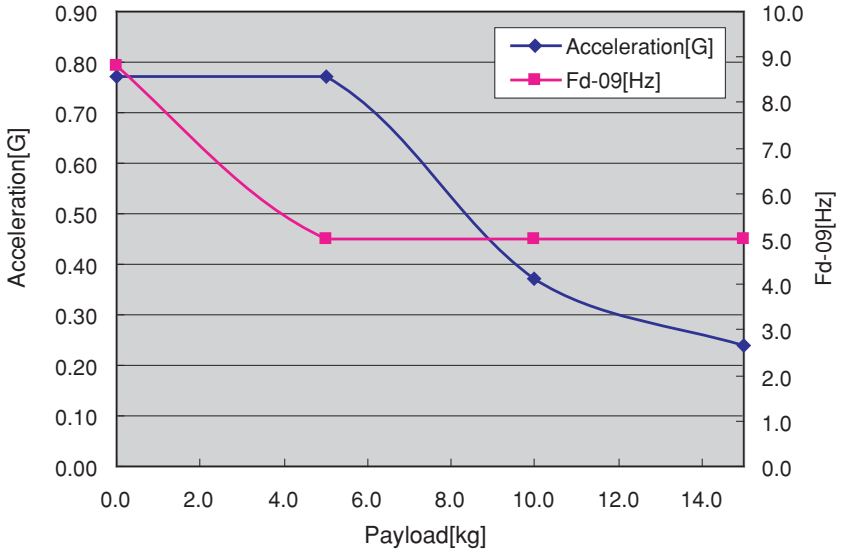


Model	F10-30

Maximum payload [kg] 15.0 [kg]

Fd-00 Moment of inertia 0.553 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 90.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.77	8.8
5.0	0.77	5.0
10.0	0.37	5.0
15.0	0.24	5.0

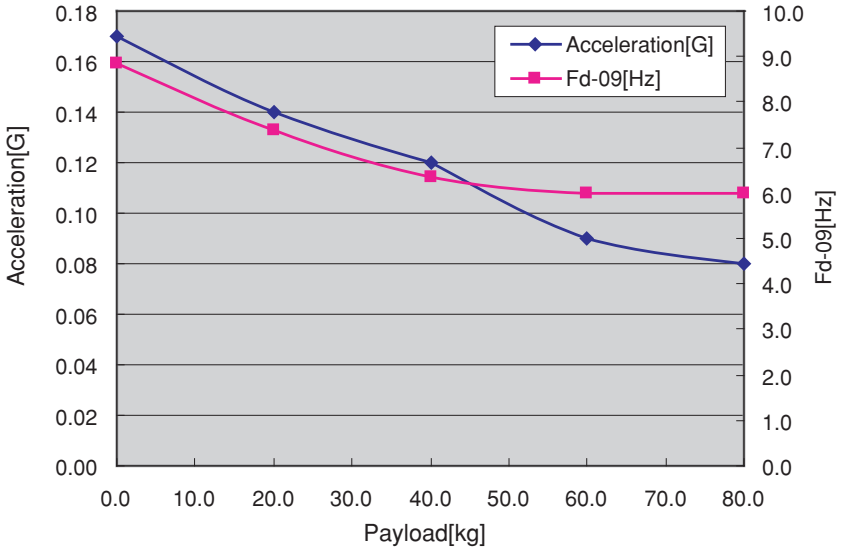


Model	F14-5 (C14-5)

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 0.282 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.17	8.8
20.0	0.14	7.4
40.0	0.12	6.3
60.0	0.09	6.0
80.0	0.08	6.0

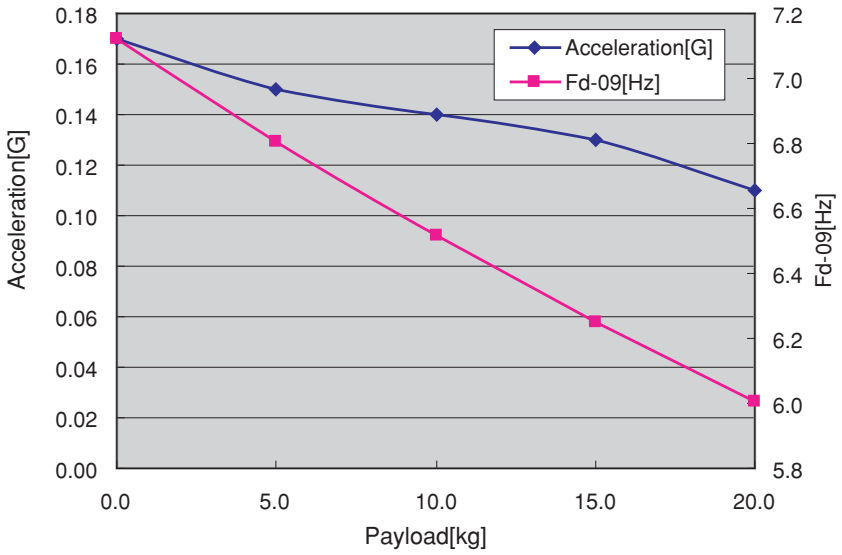


Model	F14-5-BK (C14-5-BK)

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.282 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.17	7.1
5.0	0.15	6.8
10.0	0.14	6.5
15.0	0.13	6.3
20.0	0.11	6.0

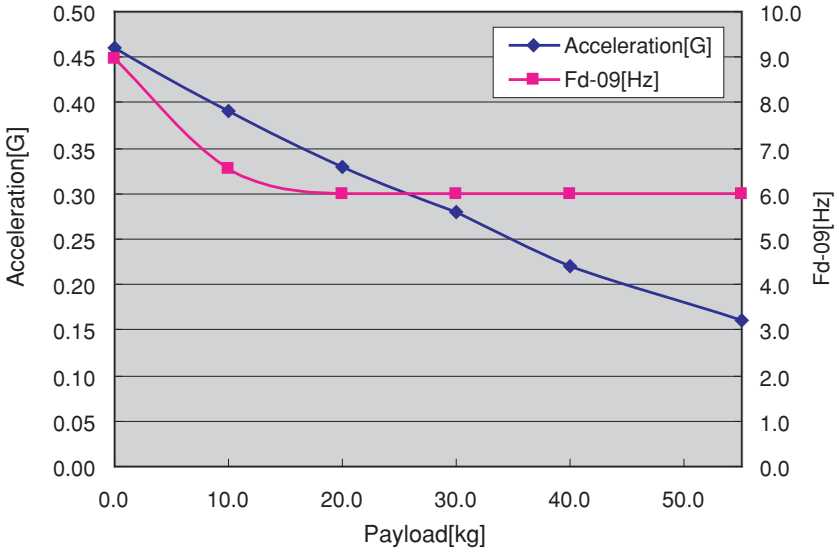


Model	F14-10 (C14-10)

Maximum payload [kg] 55.0 [kg]

Fd-00 Moment of inertia 0.304 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.46	9.0
10.0	0.39	6.5
20.0	0.33	6.0
30.0	0.28	6.0
40.0	0.22	6.0
55.0	0.16	6.0

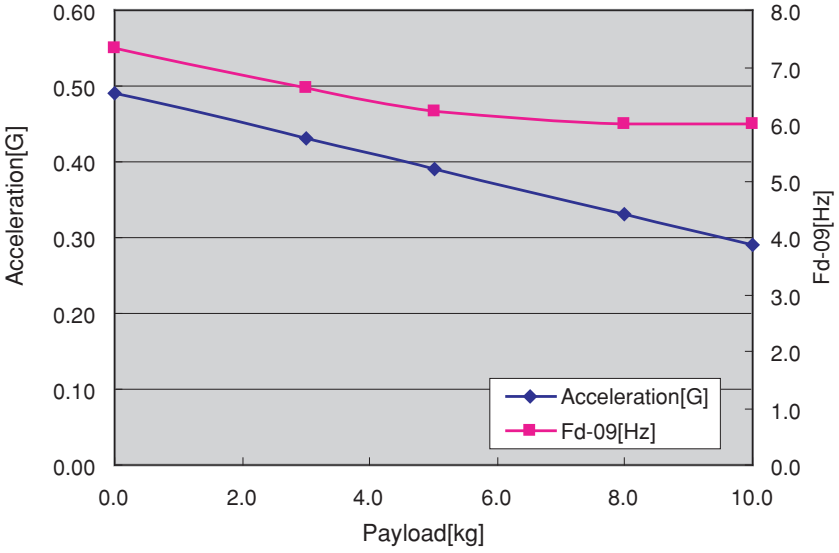


Model	F14-10-BK (C14-10-BK)

Maximum payload [kg] 10.0 [kg]

Fd-00 Moment of inertia 0.304 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.49	7.3
3.0	0.43	6.6
5.0	0.39	6.2
8.0	0.33	6.0
10.0	0.29	6.0

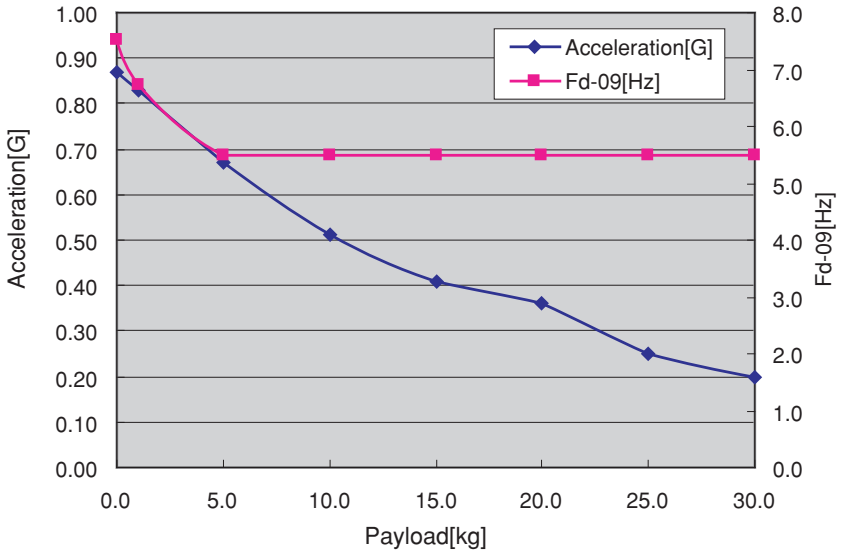


Model	F14-20 (C14-20)

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 0.399 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.87	7.5
1.0	0.83	6.7
5.0	0.67	5.5
10.0	0.51	5.5
15.0	0.41	5.5
20.0	0.36	5.5
25.0	0.25	5.5
30.0	0.20	5.5

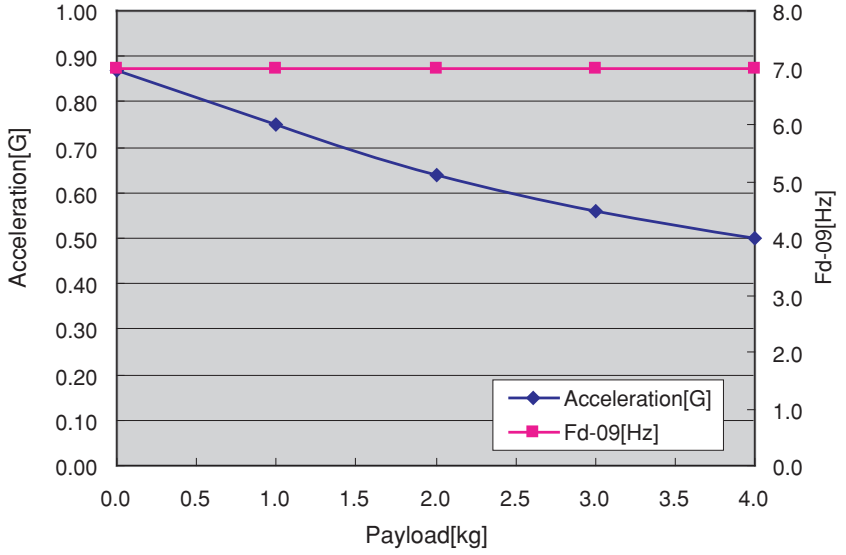


Model	F14-20-BK (C14-20-BK)

Maximum payload [kg] 4.0 [kg]

Fd-00 Moment of inertia 0.399 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.87	7.0
1.0	0.75	7.0
2.0	0.64	7.0
3.0	0.56	7.0
4.0	0.50	7.0

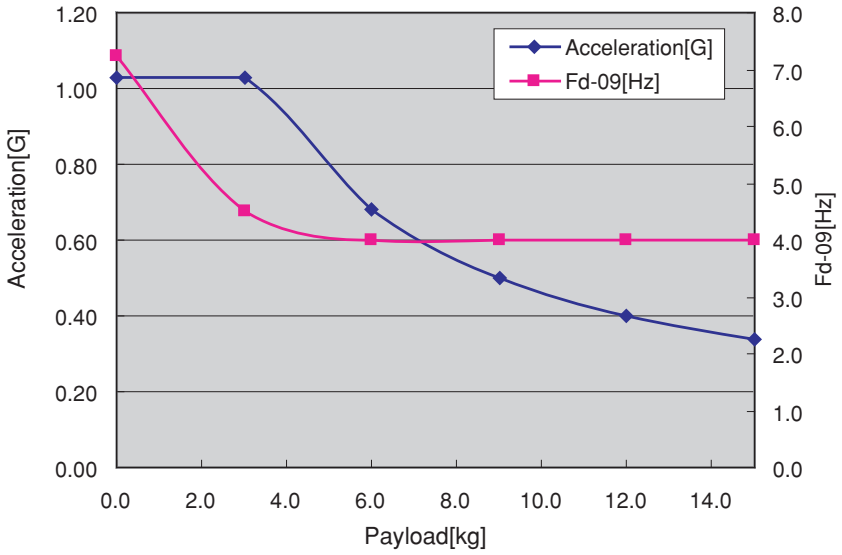


Model	F14-30

Maximum payload [kg] 15.0 [kg]

Fd-00 Moment of inertia 0.501 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 90.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.03	7.2
3.0	1.03	4.5
6.0	0.68	4.0
9.0	0.50	4.0
12.0	0.40	4.0
15.0	0.34	4.0

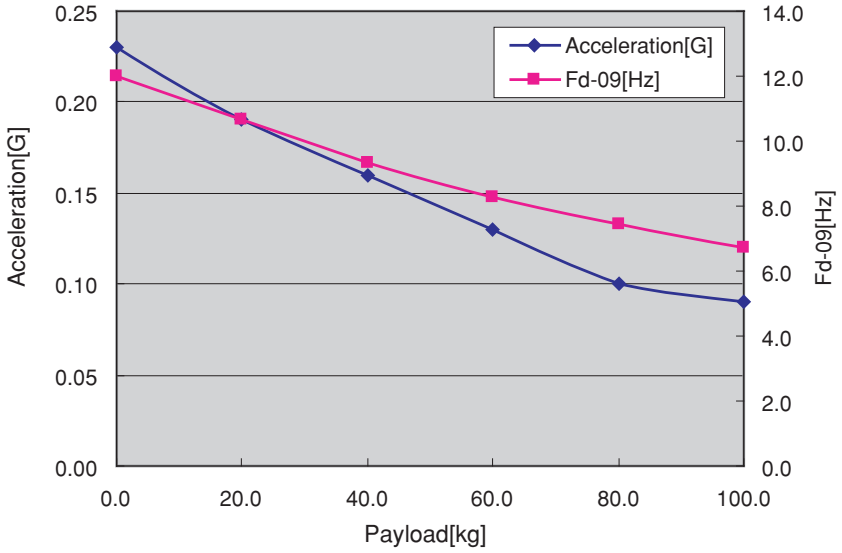


Model	F14H-5 (C14H-5)

Maximum payload [kg] 100.0 [kg]

Fd-00 Moment of inertia 0.600 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 50.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.23	12.0
20.0	0.19	10.7
40.0	0.16	9.3
60.0	0.13	8.3
80.0	0.10	7.4
100.0	0.09	6.7

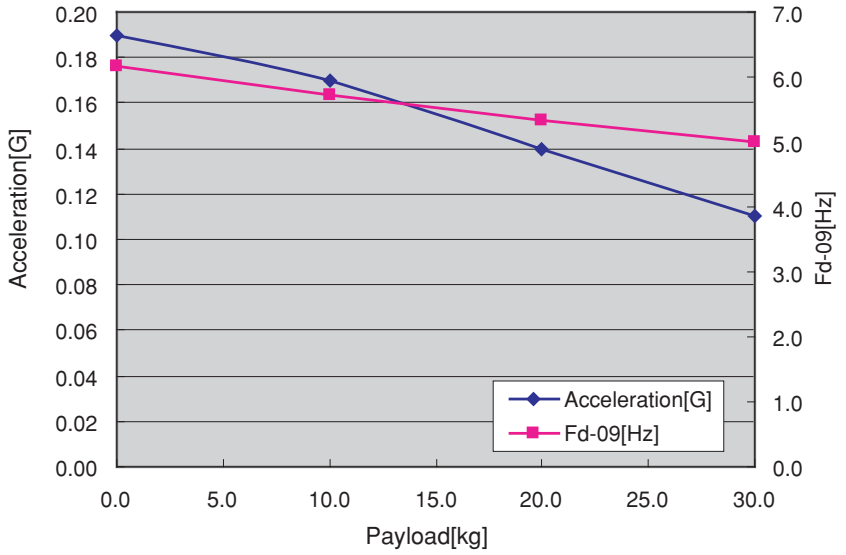


Model	F14H-5-BK (C14H-5-BK)

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 0.388 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.19	6.2
10.0	0.17	5.7
20.0	0.14	5.3
30.0	0.11	5.0

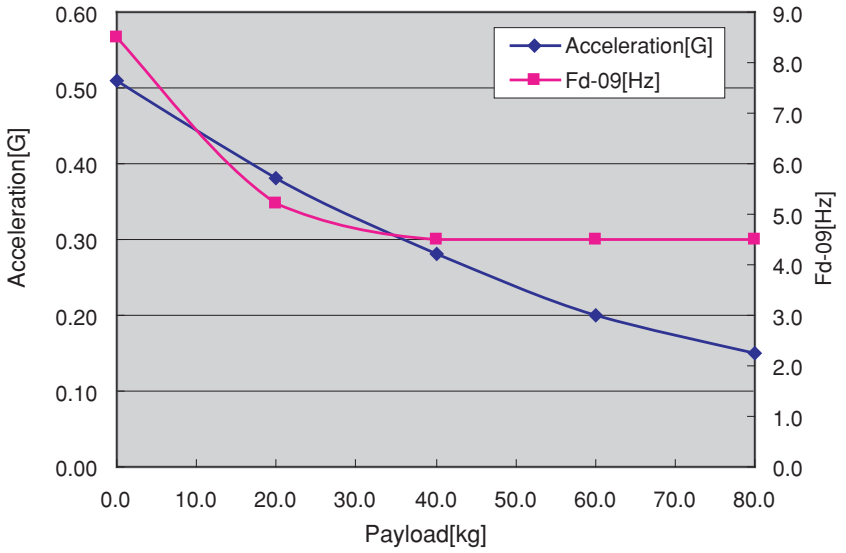


Model	F14H-10 (C14H-10)

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 0.424 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.51	8.5
20.0	0.38	5.2
40.0	0.28	4.5
60.0	0.20	4.5
80.0	0.15	4.5

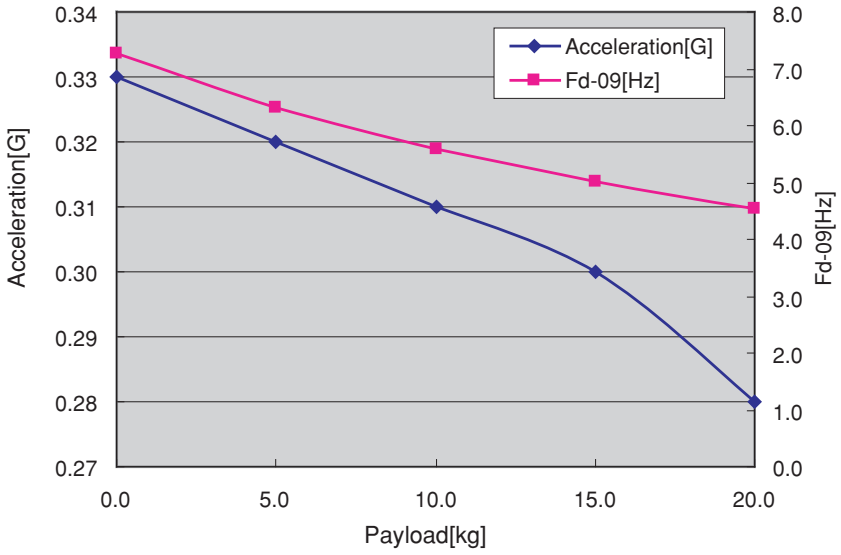


Model	F14H-10-BK (C14H-10-BK)

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.424 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.33	7.3
5.0	0.32	6.3
10.0	0.31	5.6
15.0	0.30	5.0
20.0	0.28	4.5

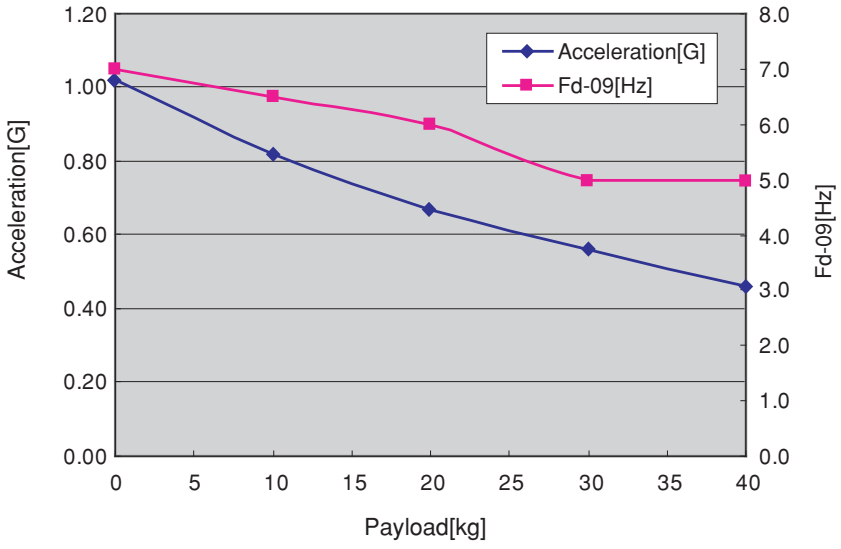


Model	F14H-20 (C14H-20)

Maximum payload [kg] 40.0 [kg]

Fd-00 Moment of inertia 0.557 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 40.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.02	7.0
10.0	0.82	6.5
20.0	0.67	6.0
30.0	0.56	5.0
40.0	0.46	5.0

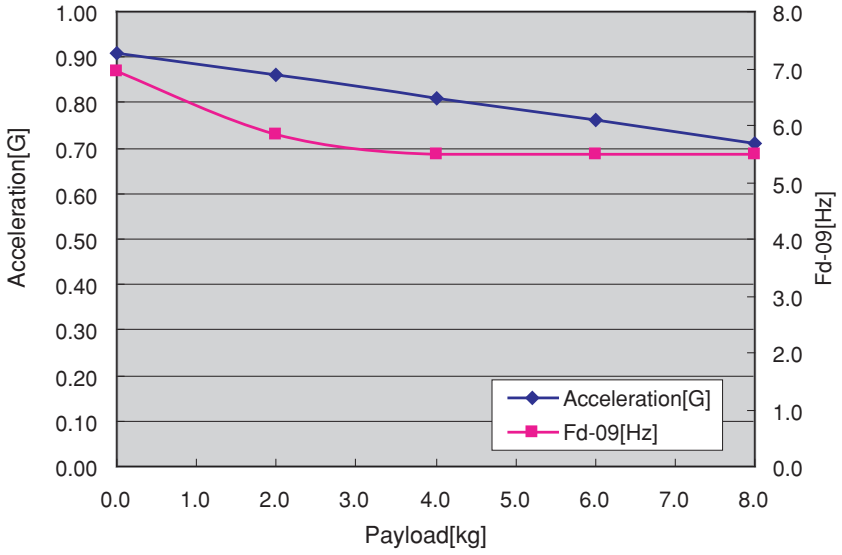


Model	F14H-20-BK (C14H-20-BK)

Maximum payload [kg] 8.0 [kg]

Fd-00 Moment of inertia 0.620 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 60.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.91	7.0
2.0	0.86	5.8
4.0	0.81	5.5
6.0	0.76	5.5
8.0	0.71	5.5

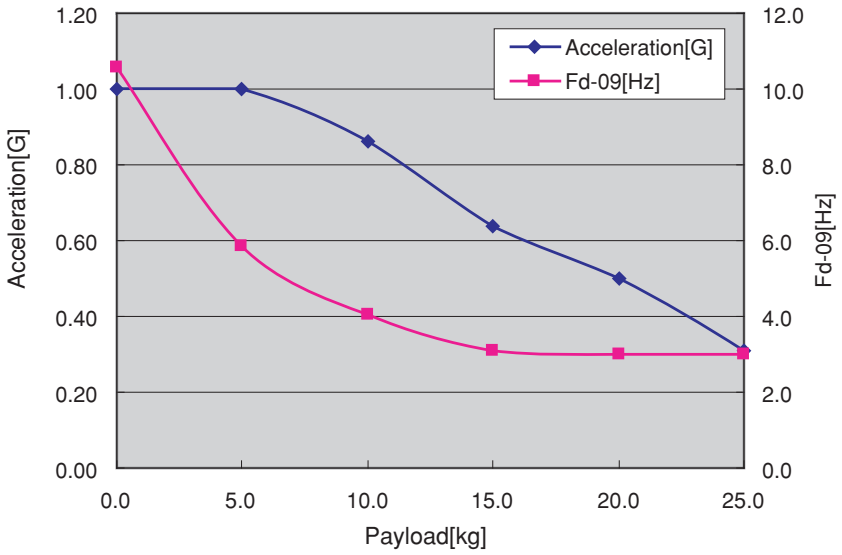


Model	F14H-30

Maximum payload [kg] 25.0 [kg]

Fd-00 Moment of inertia 0.823 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 90.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.00	10.6
5.0	1.00	5.8
10.0	0.86	4.0
15.0	0.64	3.1
20.0	0.50	3.0
25.0	0.31	3.0

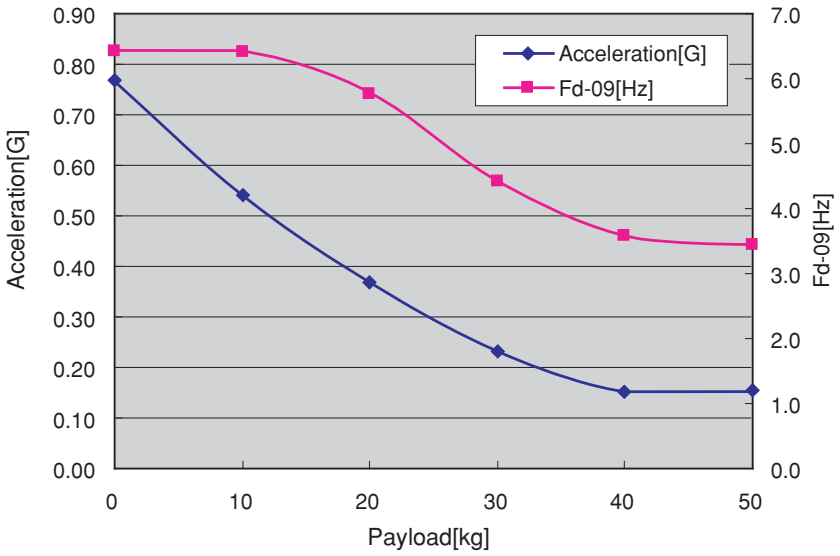


Model	F17L-50 (C17L-50)

Maximum payload [kg] 50.0 [kg]

Fd-00 Moment of inertia 6.080 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.77	6.5
10.0	0.55	6.5
20.0	0.37	5.9
30.0	0.24	4.5
40.0	0.16	3.6
50.0	0.16	3.5

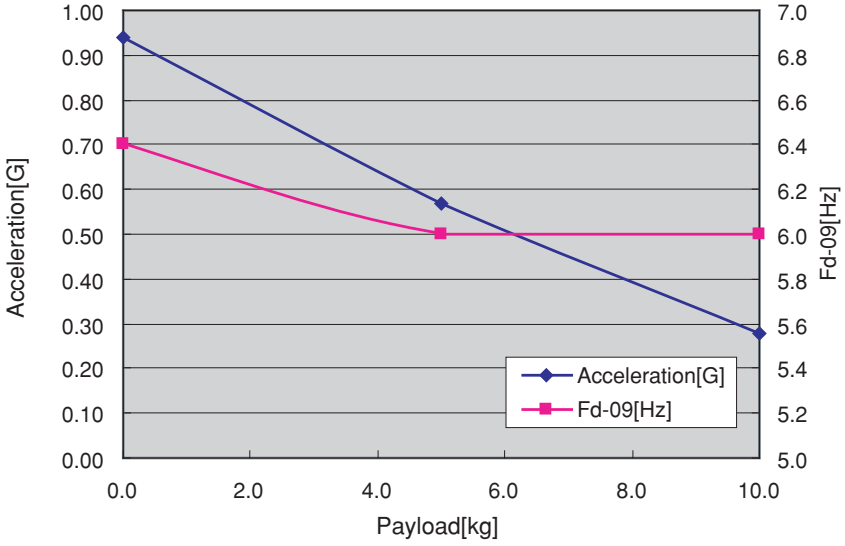


Model	F17L-50-BK (C17L-50-BK)

Maximum payload [kg] 10.0 [kg]

Fd-00 Moment of inertia 6.420 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 50.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.94	6.4
5.0	0.57	6.0
10.0	0.28	6.0

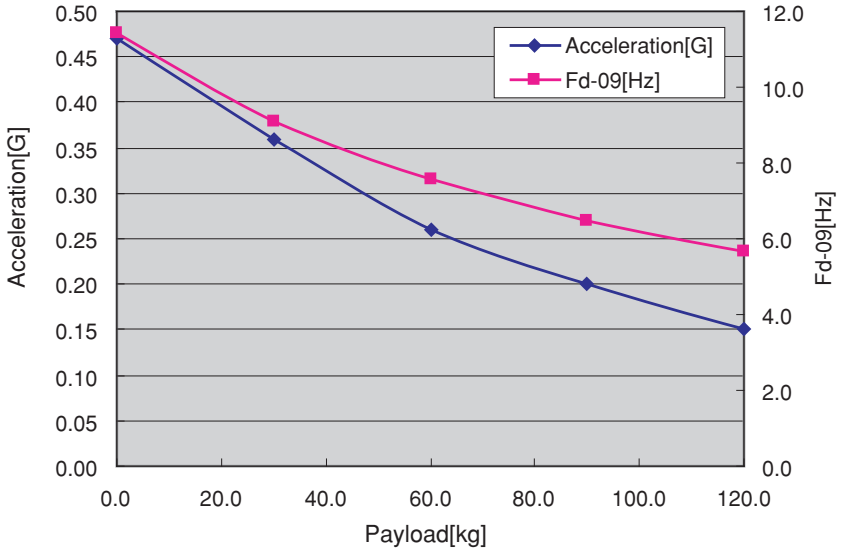


Model	F17-10 (C17-10)

Maximum payload [kg] 120.0 [kg]

Fd-00 Moment of inertia 1.480 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.47	11.4
30.0	0.36	9.1
60.0	0.26	7.6
90.0	0.20	6.5
120.0	0.15	5.7

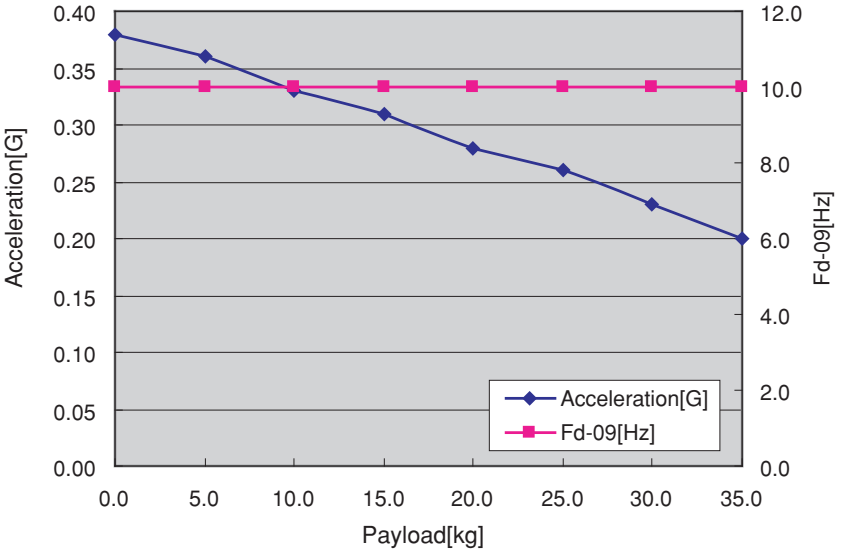


Model	F17-10-BK (C17-10-BK)

Maximum payload [kg] 35.0 [kg]

Fd-00 Moment of inertia 1.480 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 90.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.38	10.0
5.0	0.36	10.0
10.0	0.33	10.0
15.0	0.31	10.0
20.0	0.28	10.0
25.0	0.26	10.0
30.0	0.23	10.0
35.0	0.20	10.0

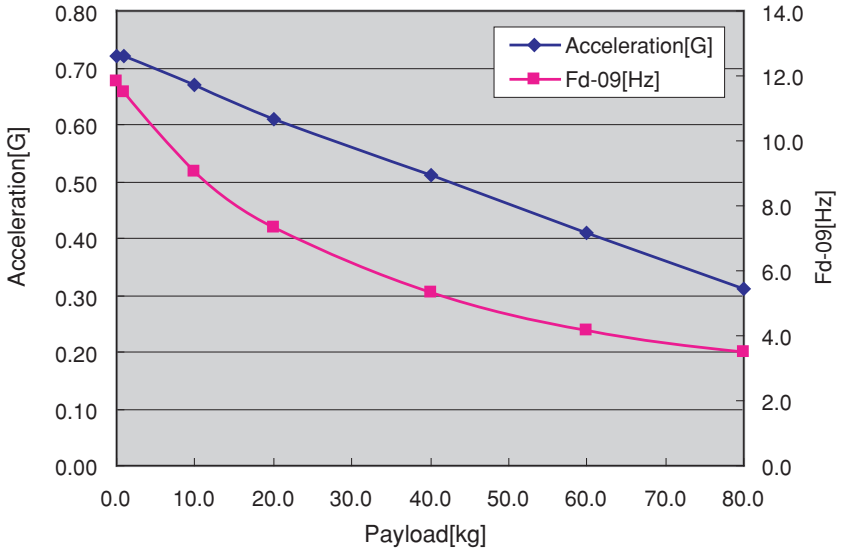


Model	F17-20 (C17-20)

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 1.720 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.72	11.8
1.0	0.72	11.5
10.0	0.67	9.1
20.0	0.61	7.3
40.0	0.51	5.3
60.0	0.41	4.2
80.0	0.31	3.5

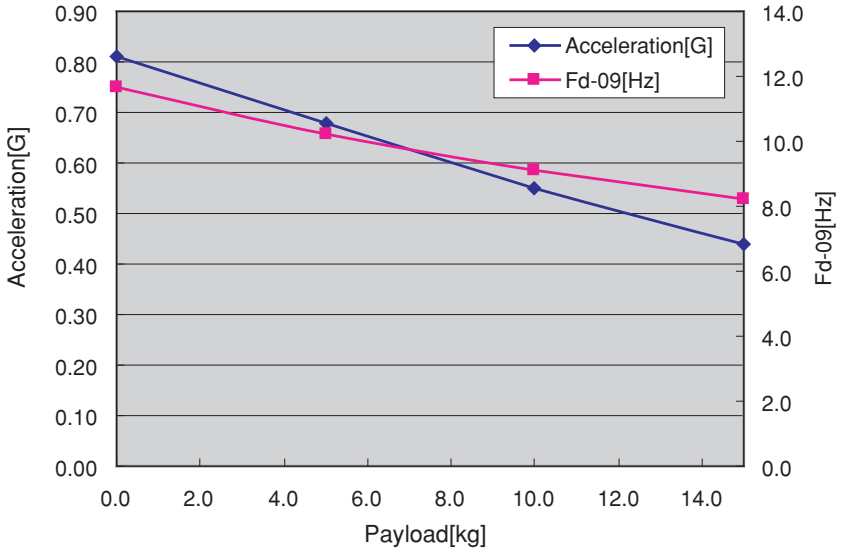


Model	F17-20-BK (C17-20-BK)

Maximum payload [kg] 15.0 [kg]

Fd-00 Moment of inertia 2.060 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 85.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.81	11.6
5.0	0.68	10.2
10.0	0.55	9.1
15.0	0.44	8.2

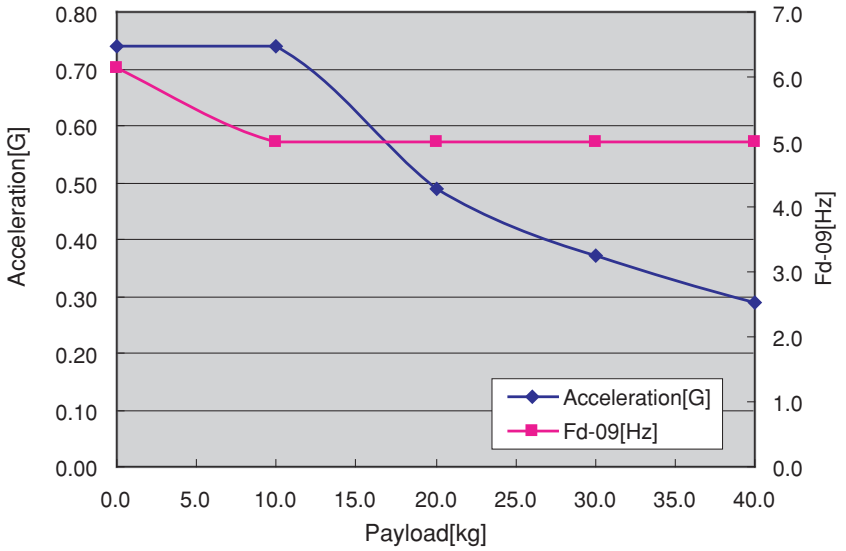


Model	F17-40

Maximum payload [kg] 40.0 [kg]

Fd-00 Moment of inertia 1.930 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.74	6.1
10.0	0.74	5.0
20.0	0.49	5.0
30.0	0.37	5.0
40.0	0.29	5.0

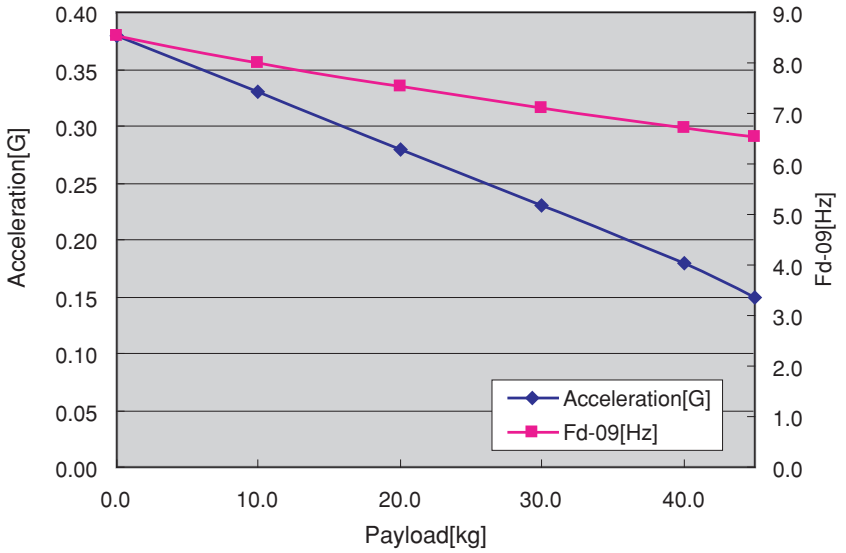


Model	F20-10-BK (C20-10-BK)

Maximum payload [kg] 45.0 [kg]

Fd-00 Moment of inertia 2.210 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.38	8.5
10.0	0.33	8.0
20.0	0.28	7.5
30.0	0.23	7.1
40.0	0.18	6.7
45.0	0.15	6.5

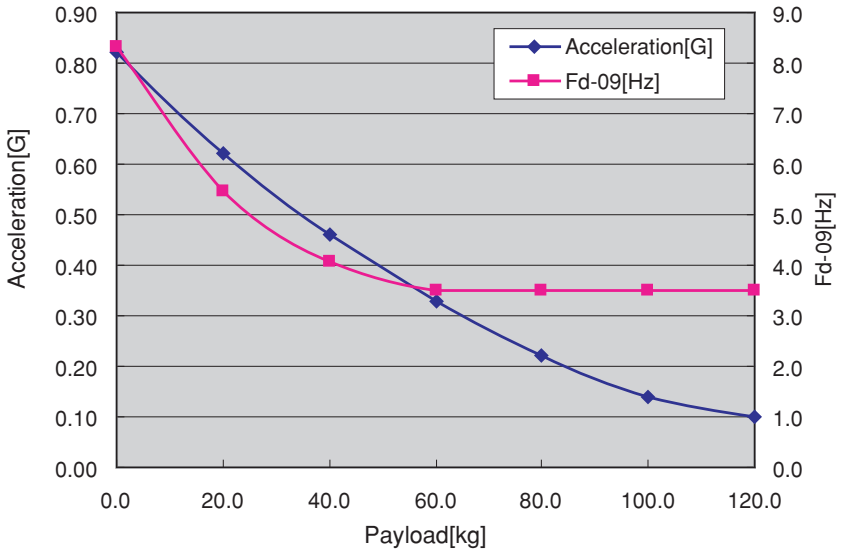


Model	F20-20 (C20-20)

Maximum payload [kg] 120.0 [kg]

Fd-00 Moment of inertia 2.250 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.82	8.3
20.0	0.62	5.5
40.0	0.46	4.1
60.0	0.33	3.5
80.0	0.22	3.5
100.0	0.14	3.5
120.0	0.10	3.5

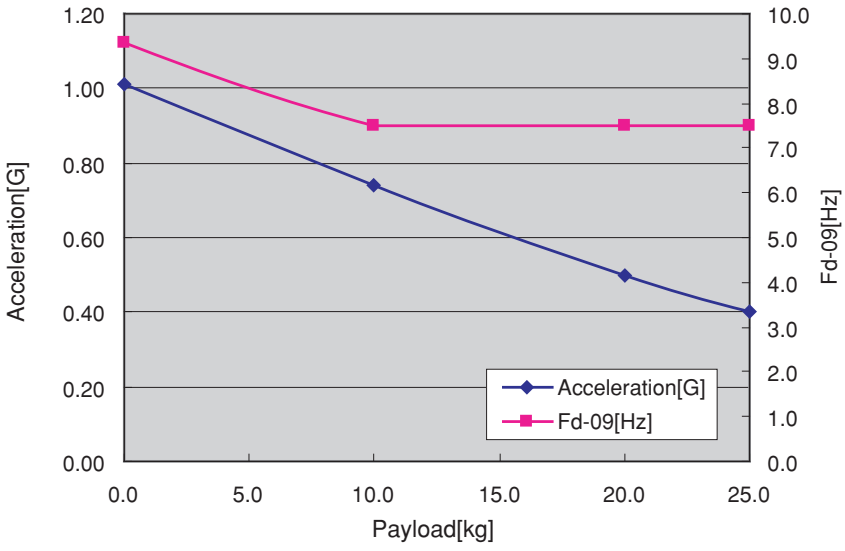


Model	F20-20-BK (C20-20-BK)

Maximum payload [kg] 25.0 [kg]

Fd-00 Moment of inertia 2.460 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.01	9.4
10.0	0.74	7.5
20.0	0.50	7.5
25.0	0.40	7.5

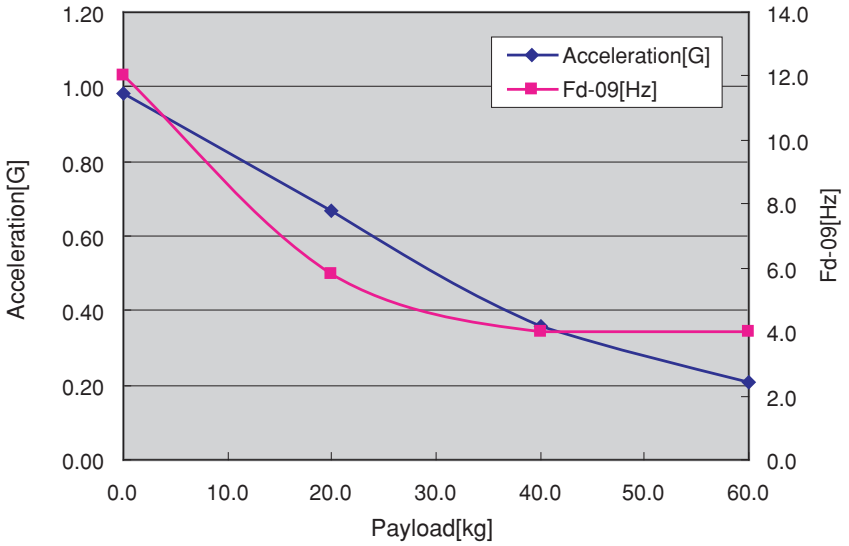


Model	F20-40

Maximum payload [kg] 60.0 [kg]

Fd-00 Moment of inertia 4.710 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 65.0 [Hz]
Fd-03 Speed control integral gain 55.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.98	12.0
20.0	0.67	5.8
40.0	0.36	4.0
60.0	0.21	4.0

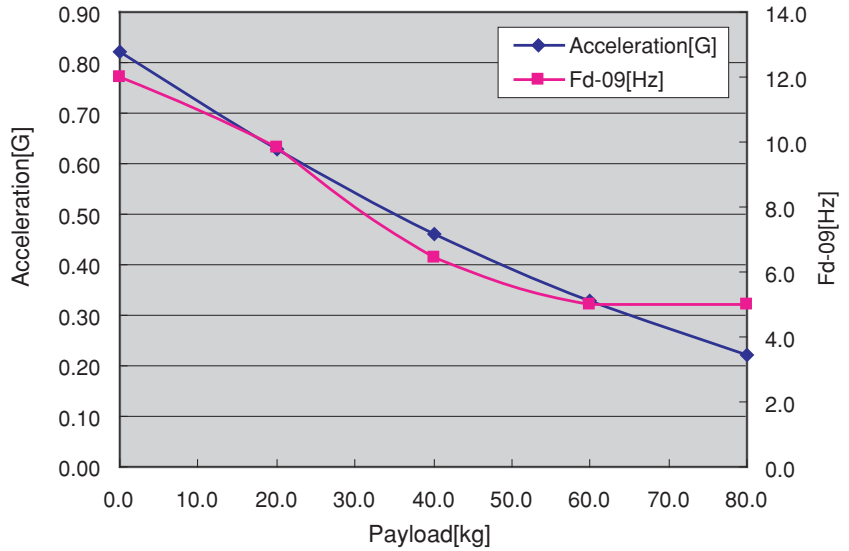


Model	F20N-20

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 1.720 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.82	12.0
20.0	0.63	9.9
40.0	0.46	6.5
60.0	0.33	5.0
80.0	0.22	5.0

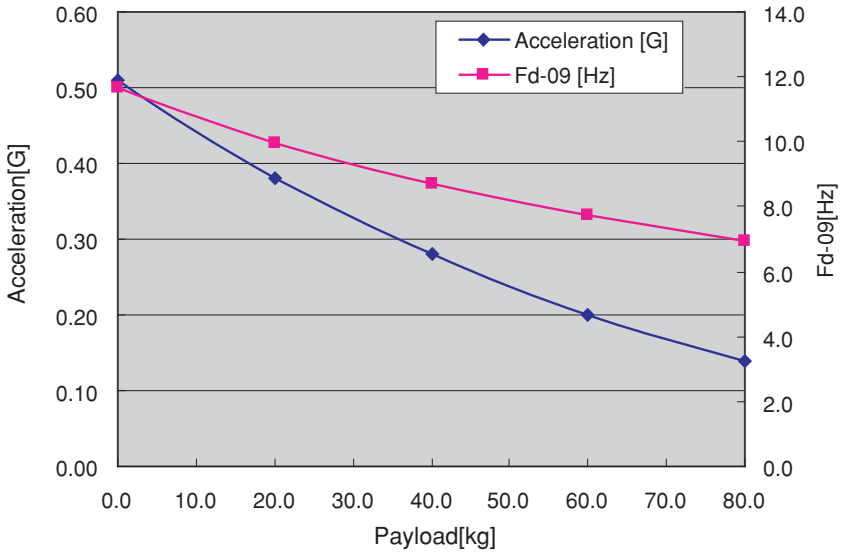


Model	N15-10

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 2.940 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.51	11.7
20.0	0.38	10.0
40.0	0.28	8.7
60.0	0.20	7.7
80.0	0.14	6.9

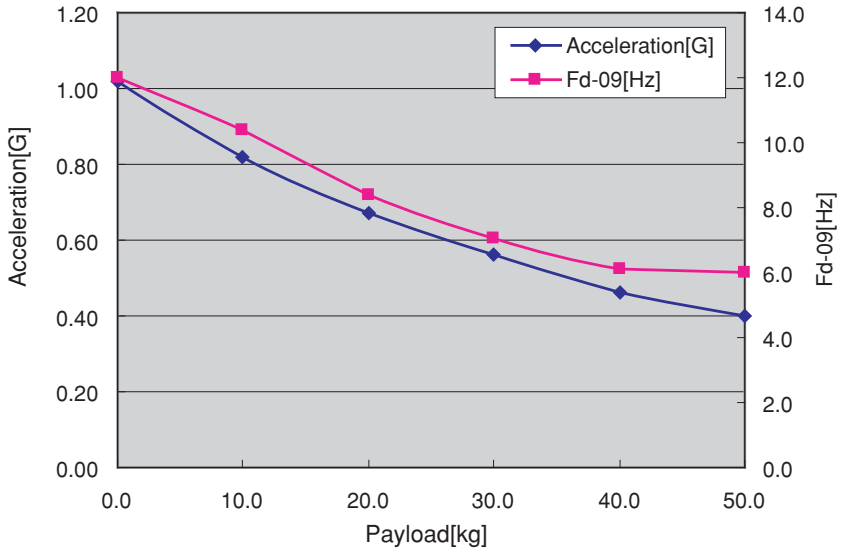


Model	N15-20

Maximum payload [kg] 50.0 [kg]

Fd-00 Moment of inertia 3.220 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.02	12.0
10.0	0.82	10.4
20.0	0.67	8.4
30.0	0.56	7.1
40.0	0.46	6.1
50.0	0.40	6.0

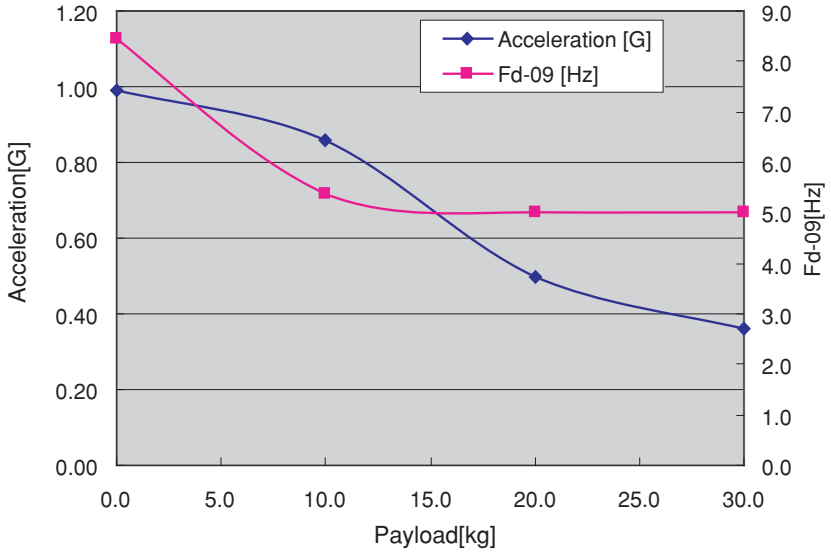


Model	N15-30

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 3.720 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 45.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.99	8.5
10.0	0.86	5.4
20.0	0.50	5.0
30.0	0.36	5.0

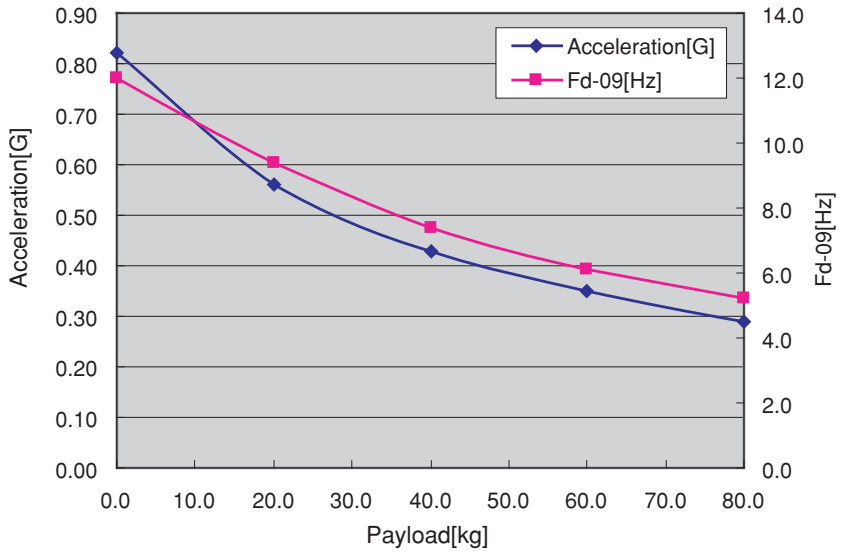


Model	N18-20

Maximum payload [kg] 80.0 [kg]

Fd-00 Moment of inertia 5.240 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.82	12.0
20.0	0.56	9.4
40.0	0.43	7.4
60.0	0.35	6.1
80.0	0.29	5.2

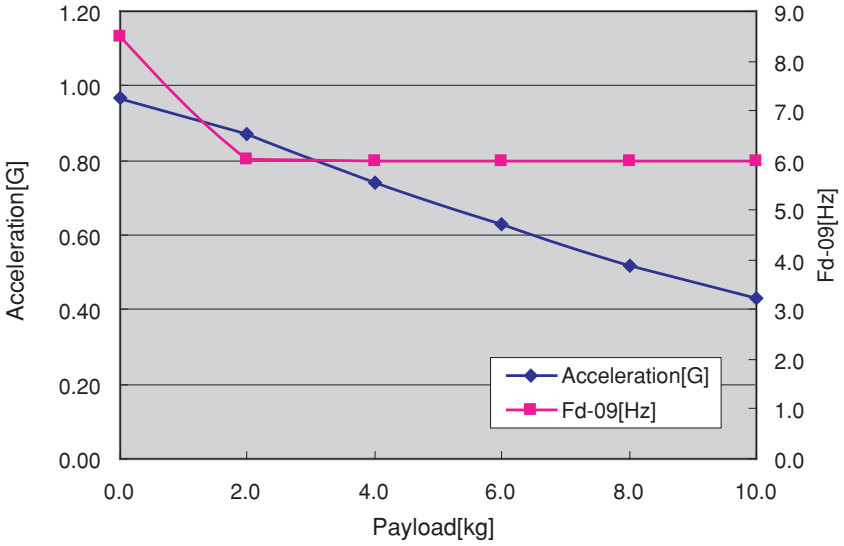


Model	B10

Maximum payload [kg] 10.0 [kg]

Fd-00 Moment of inertia 0.451 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 100.0 [Hz]
Fd-03 Speed control integral gain 75.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.97	8.5
2.0	0.87	6.0
4.0	0.74	6.0
6.0	0.63	6.0
8.0	0.52	6.0
10.0	0.43	6.0

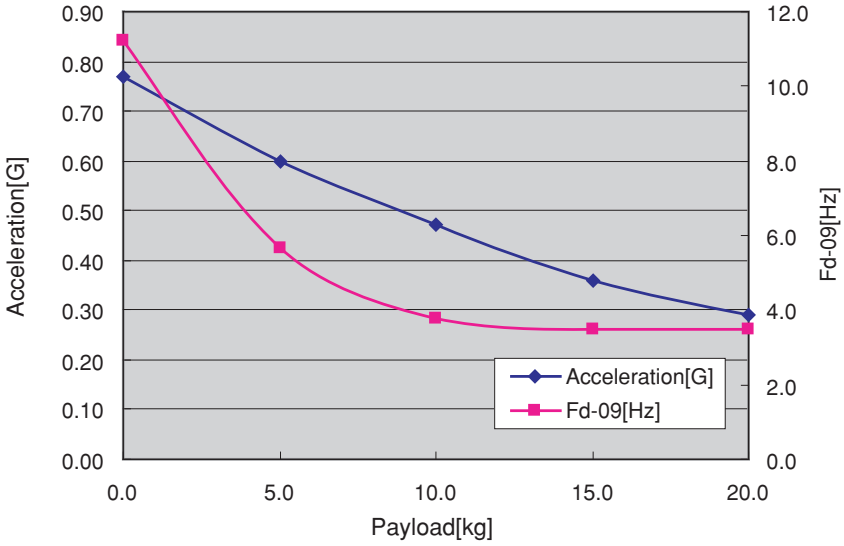


Model	B14

Maximum payload [kg] 20.0 [kg]

Fd-00 Moment of inertia 0.643 [$\times 10^{-4}$kg•m^2]
Fd-01 Speed control cut-off frequency 70.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	0.77	11.2
5.0	0.60	5.7
10.0	0.47	3.8
15.0	0.36	3.5
20.0	0.29	3.5

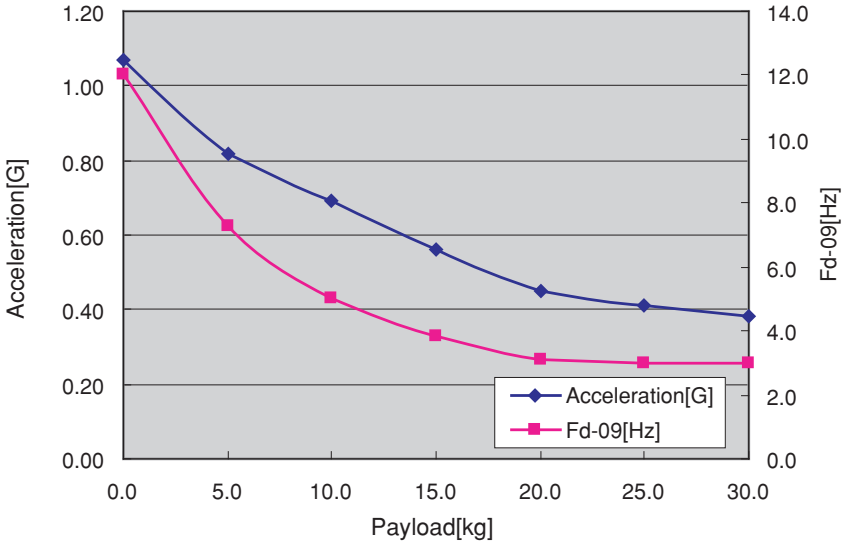


Model	B14H

Maximum payload [kg] 30.0 [kg]

Fd-00 Moment of inertia 0.800 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 80.0 [Hz]
Fd-03 Speed control integral gain 40.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.07	12.0
5.0	0.82	7.3
10.0	0.69	5.0
15.0	0.56	3.8
20.0	0.45	3.1
25.0	0.41	3.0
30.0	0.38	3.0

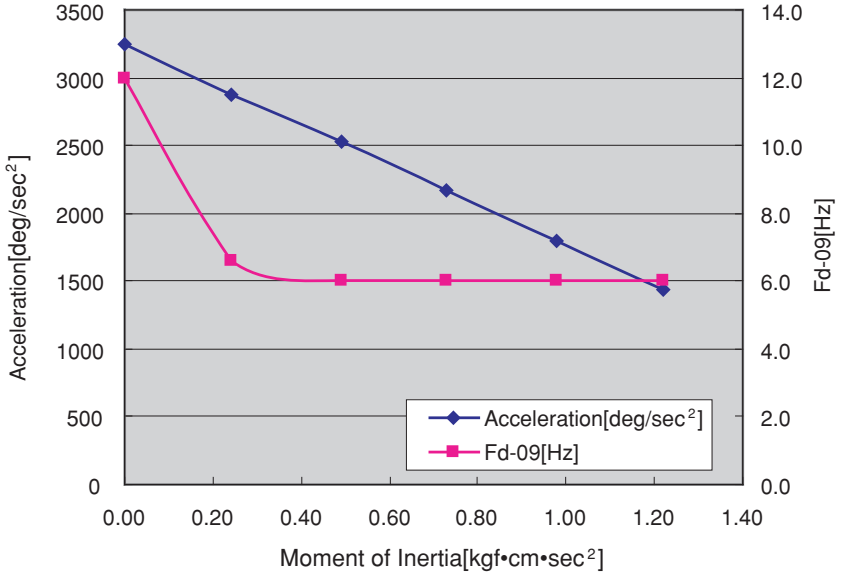


Model	R5

Moment of inertia of maximum allowable load 1.22 [kgf•cm•sec^2]

Fd-00 Moment of inertia 0.235 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 60.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Moment of inertia of load [kgf•cm•sec^2]	Acceleration [deg/sec^2]	Fd-09 [Hz]
0.00	3243	12.0
0.24	2880	6.6
0.49	2535	6.0
0.73	2169	6.0
0.98	1800	6.0
1.22	1440	6.0

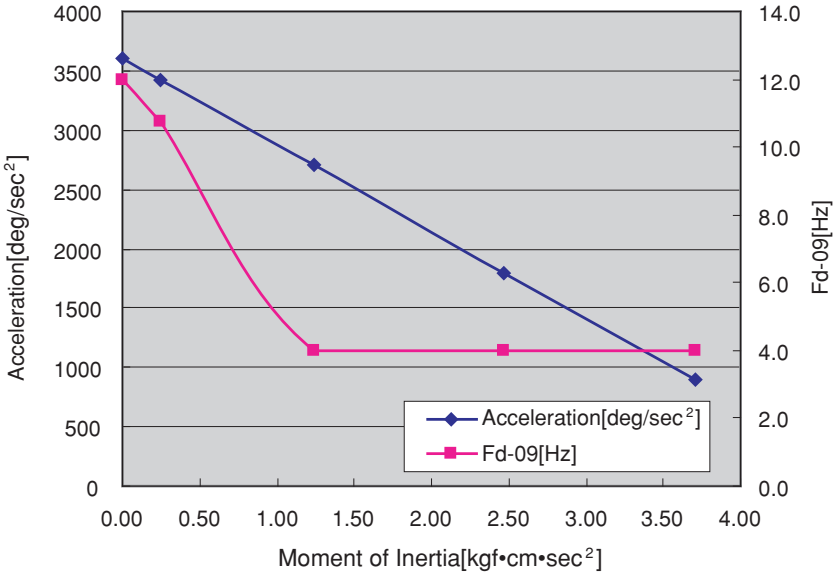


Model	R10

Moment of inertia of maximum allowable load 3.71 [kgf•cm•sec^2]

Fd-00 Moment of inertia 0.239 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 60.0 [%]

Moment of inertia of load [kgf•cm•sec^2]	Acceleration [deg/sec^2]	Fd-09 [Hz]
0.00	3600	12.0
0.25	3429	10.8
1.24	2707	4.0
2.47	1800	4.0
3.71	898	4.0

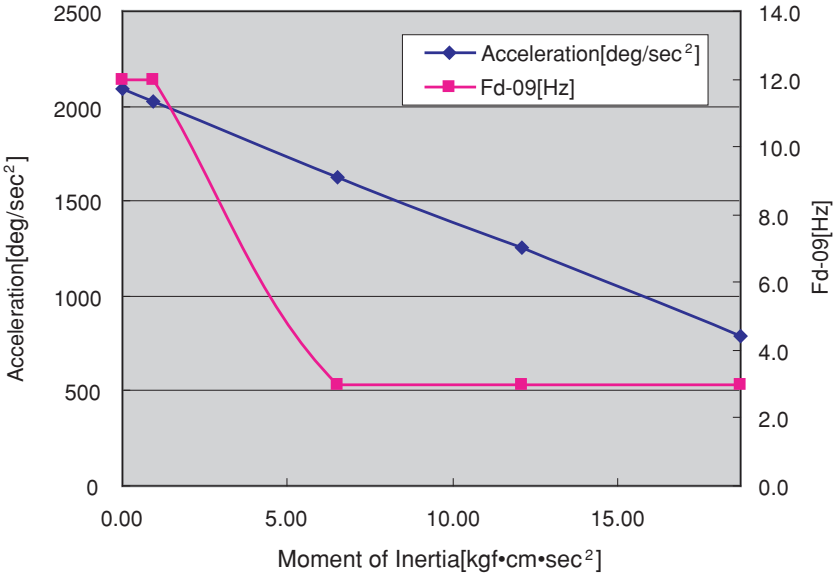


Model	R20

Moment of inertia of maximum allowable load 18.70 [kgf•cm•sec^2]

Fd-00 Moment of inertia 0.644 [×10^{-4}kg•m^2]
Fd-01 Speed control cut-off frequency 150.0 [Hz]
Fd-03 Speed control integral gain 30.0 [%]

Moment of inertia of load [kgf•cm•sec^2]	Acceleration [deg/sec^2]	Fd-09 [Hz]
0.00	2093	12.0
0.93	2022	12.0
6.50	1622	3.0
12.10	1259	3.0
18.70	791	3.0



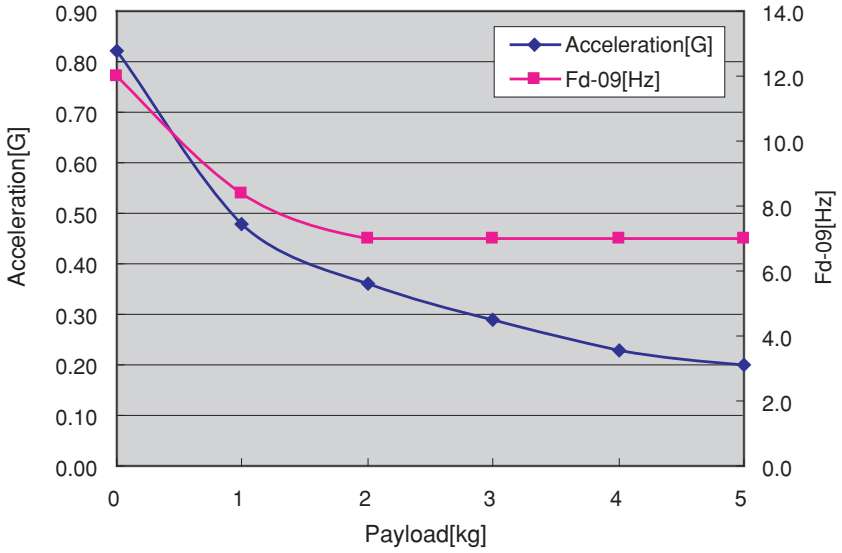
■ RDP

Model	MR12

Maximum payload [kg] 5.0 [kg]

Fd-00 Mover mass 0.108 [×10kg]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	0.82	12.0
1	0.48	8.4
2	0.36	7.0
3	0.29	7.0
4	0.23	7.0
5	0.20	7.0

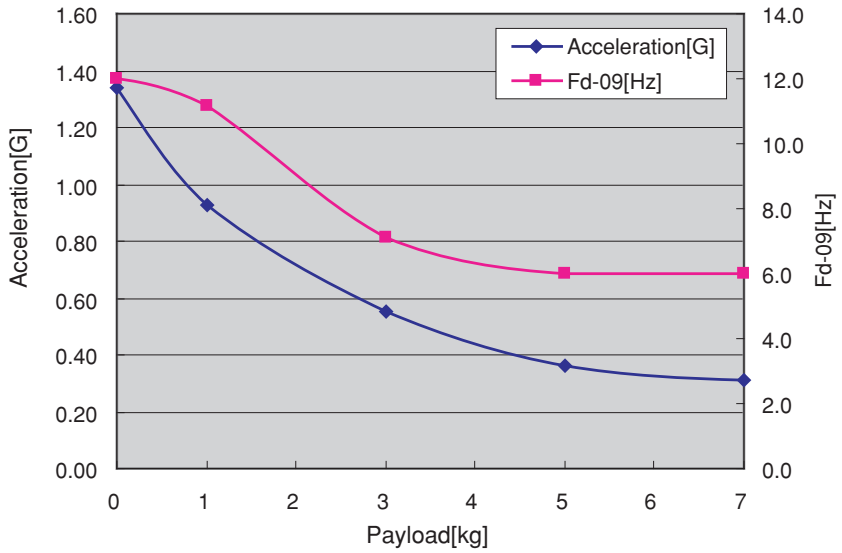


Model	MR16

Maximum payload [kg] 7.0 [kg]

Fd-00 Mover mass 0.151 [×10kg]
Fd-01 Speed control cut-off frequency 130.0 [Hz]
Fd-03 Speed control integral gain 50.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	1.34	12.0
1	0.93	11.2
3	0.55	7.1
5	0.36	6.0
7	0.31	6.0

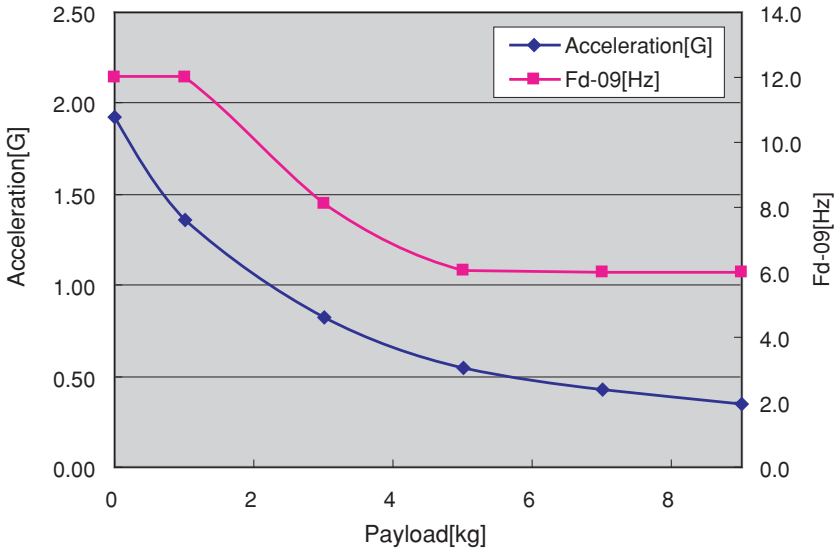


Model	MR16H

Maximum payload [kg] 9.0 [kg]

Fd-00 Mover mass 0.182 [×10kg]
Fd-01 Speed control cut-off frequency 130.0 [Hz]
Fd-03 Speed control integral gain 65.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	1.92	12.0
1	1.36	12.0
3	0.82	8.1
5	0.55	6.1
7	0.43	6.0
9	0.35	6.0

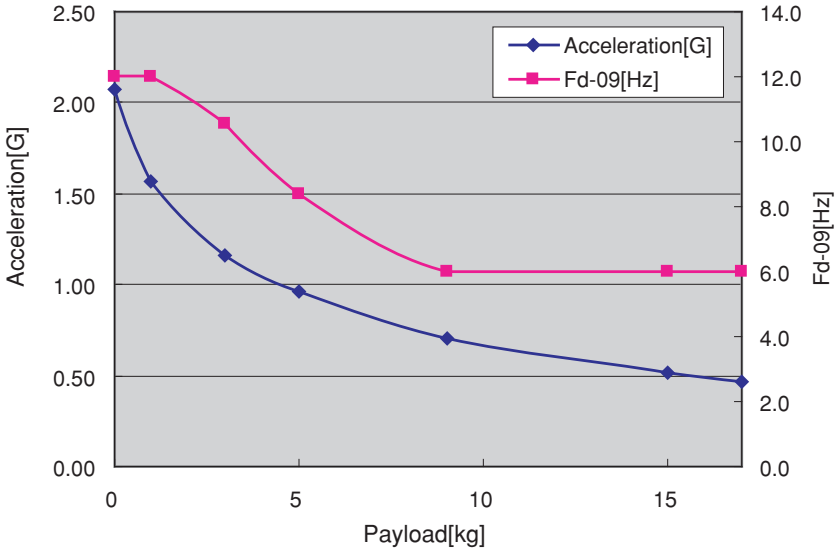


Model	MR20

Maximum payload [kg] 17.0 [kg]

Fd-00 Mover mass 0.370 [×10kg]
Fd-01 Speed control cut-off frequency 110.0 [Hz]
Fd-03 Speed control integral gain 70.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	2.07	12.0
1	1.57	12.0
3	1.16	10.6
5	0.96	8.4
9	0.70	6.0
15	0.52	6.0
17	0.47	6.0

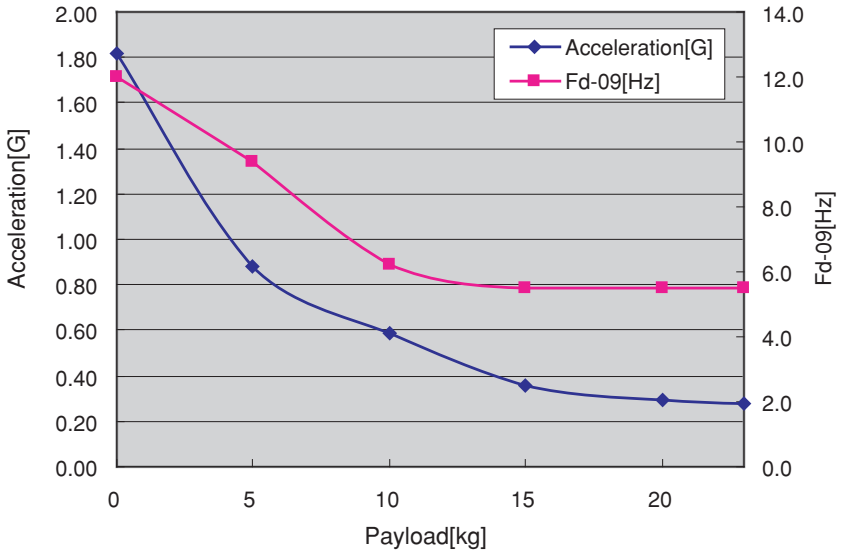


Model	MR25

Maximum payload [kg] 23.0 [kg]

Fd-00 Mover mass 0.386 [×10kg]
Fd-01 Speed control cut-off frequency 120.0 [Hz]
Fd-03 Speed control integral gain 100.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	1.82	12.0
5	0.88	9.4
10	0.59	6.2
15	0.36	5.5
20	0.29	5.5
23	0.28	5.5

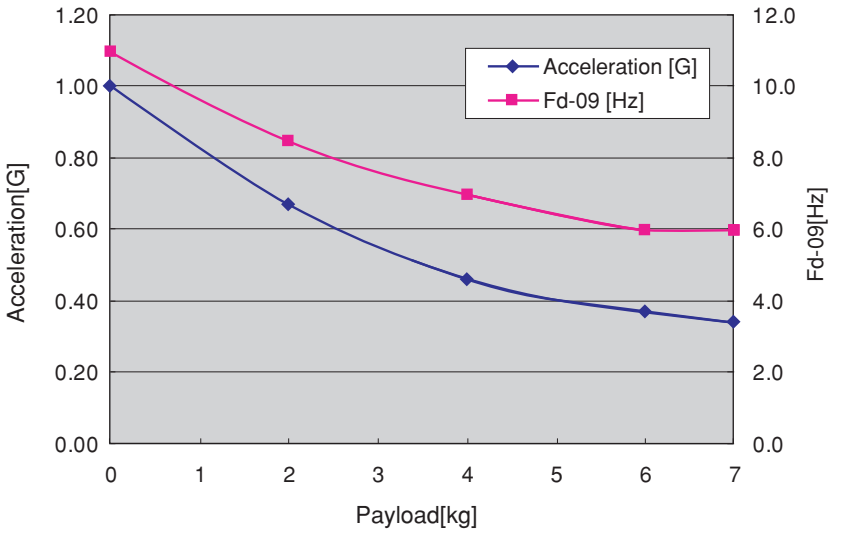


Model	MF7

Maximum payload [kg] 7.0 [kg]

Fd-00 Mover mass 0.150 [×10kg]
Fd-01 Speed control cut-off frequency 130.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	1.00	11.0
2	0.67	8.5
4	0.46	7.0
6	0.37	6.0
7	0.34	6.0

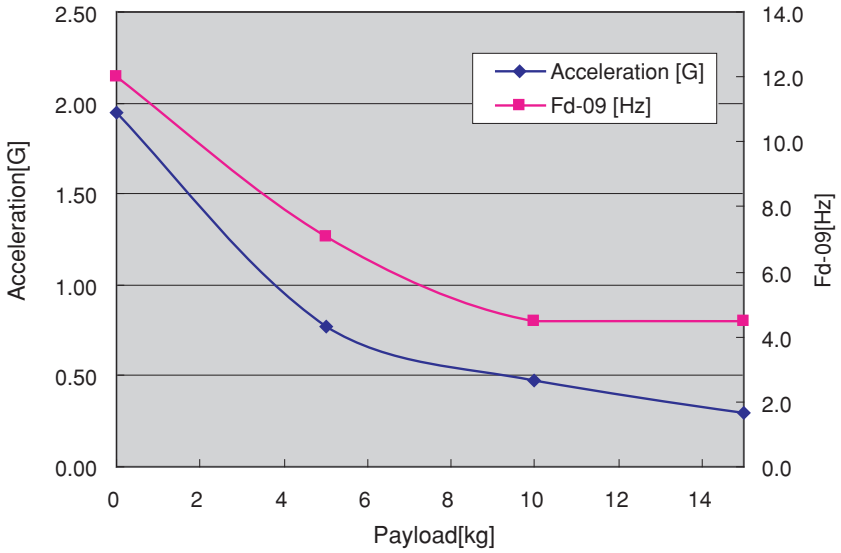


Model	MF15

Maximum payload [kg] 15.0 [kg]

Fd-00 Mover mass 0.180 [×10kg]
Fd-01 Speed control cut-off frequency 140.0 [Hz]
Fd-03 Speed control integral gain 80.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	1.95	12.0
5	0.77	7.1
10	0.47	4.5
15	0.30	4.5

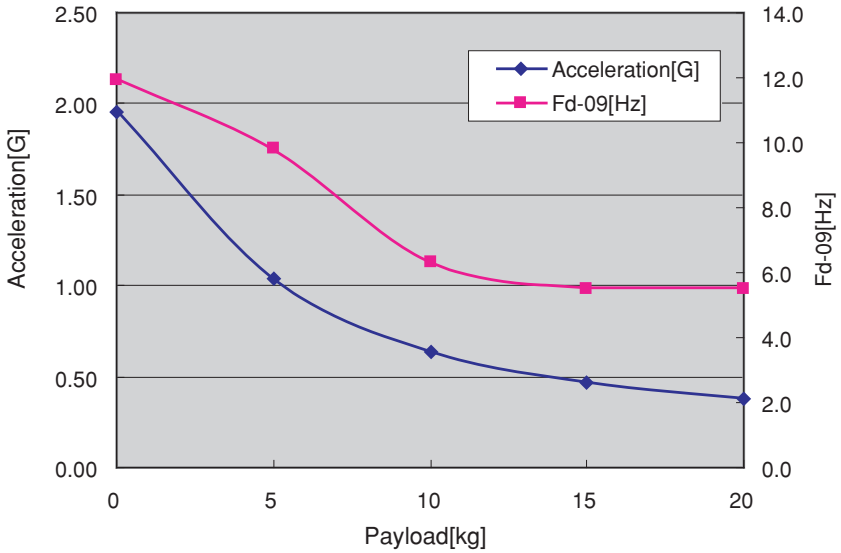


Model	MF20

Maximum payload [kg] 20.0 [kg]

Fd-00 Mover mass 0.290 [×10kg]
Fd-01 Speed control cut-off frequency 150.0 [Hz]
Fd-03 Speed control integral gain 75.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	1.95	12.0
5	1.02	9.8
10	0.62	6.3
15	0.45	5.5
20	0.36	5.5

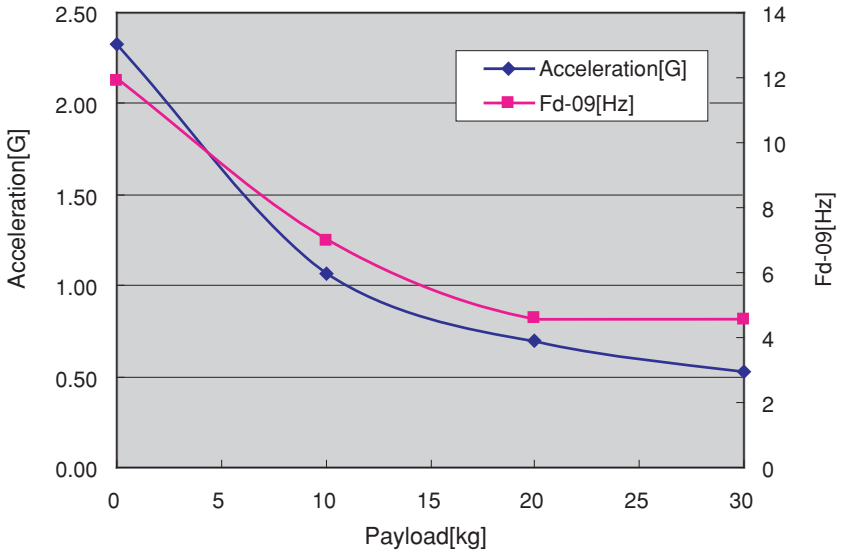


Model	MF30

Maximum payload [kg] 30.0 [kg]

Fd-00 Mover mass 0.310 [×10kg]
Fd-01 Speed control cut-off frequency 150.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	2.33	12.0
10	1.06	7
20	0.68	4.5
30	0.51	4.5

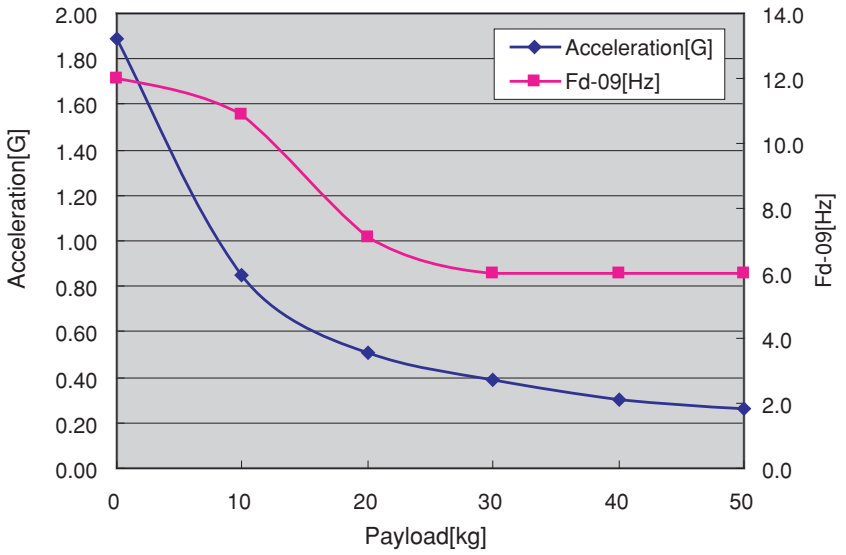


Model	MF50

Maximum payload [kg] 50.0 [kg]

Fd-00 Mover mass 0.790 [×10kg]
Fd-01 Speed control cut-off frequency 130.0 [Hz]
Fd-03 Speed control integral gain 80.0 [%]

Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0	1.89	12.0
10	0.85	10.9
20	0.51	7.1
30	0.39	6.0
40	0.30	6.0
50	0.26	6.0

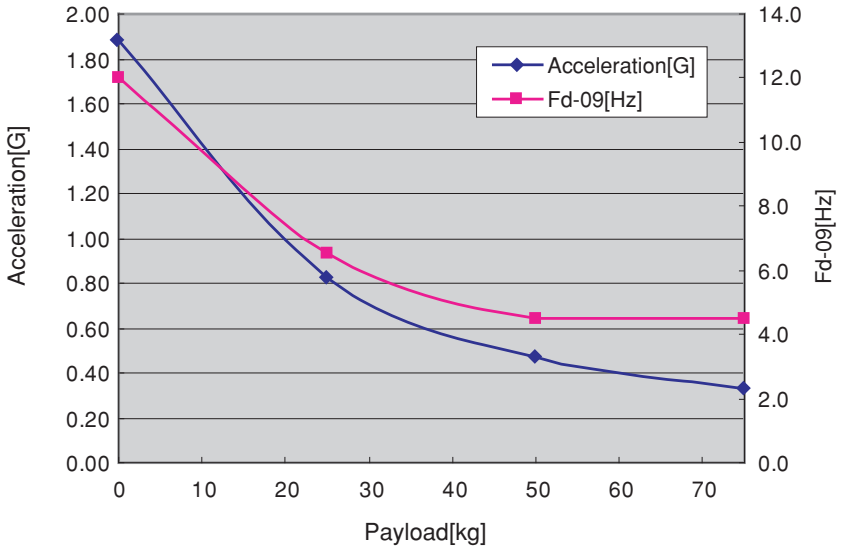


Model	MF75

Maximum payload [kg] 75.0 [kg]

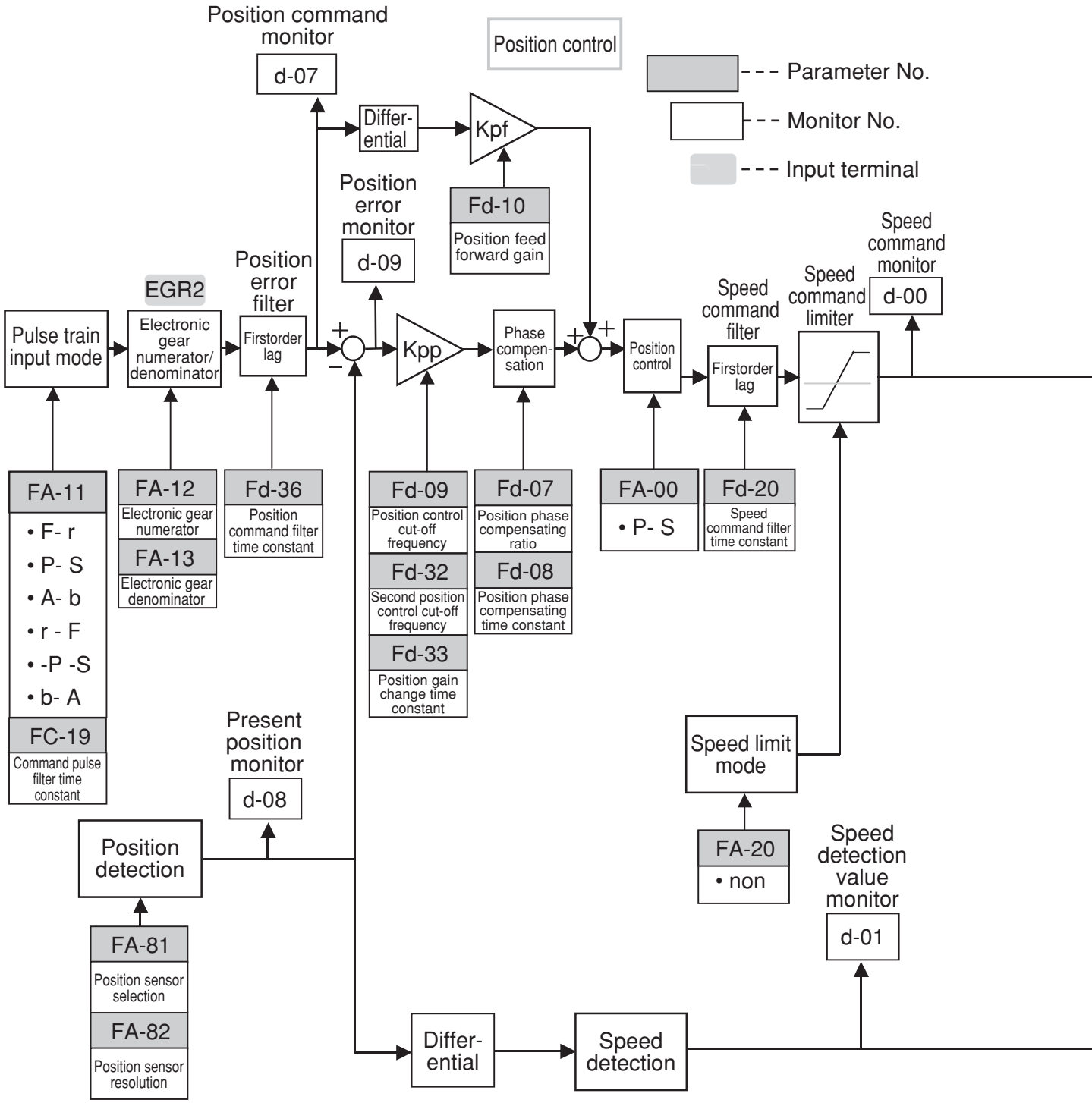
Fd-00 Mover mass 0.840 [×10kg]
Fd-01 Speed control cut-off frequency 135.0 [Hz]
Fd-03 Speed control integral gain 90.0 [%]

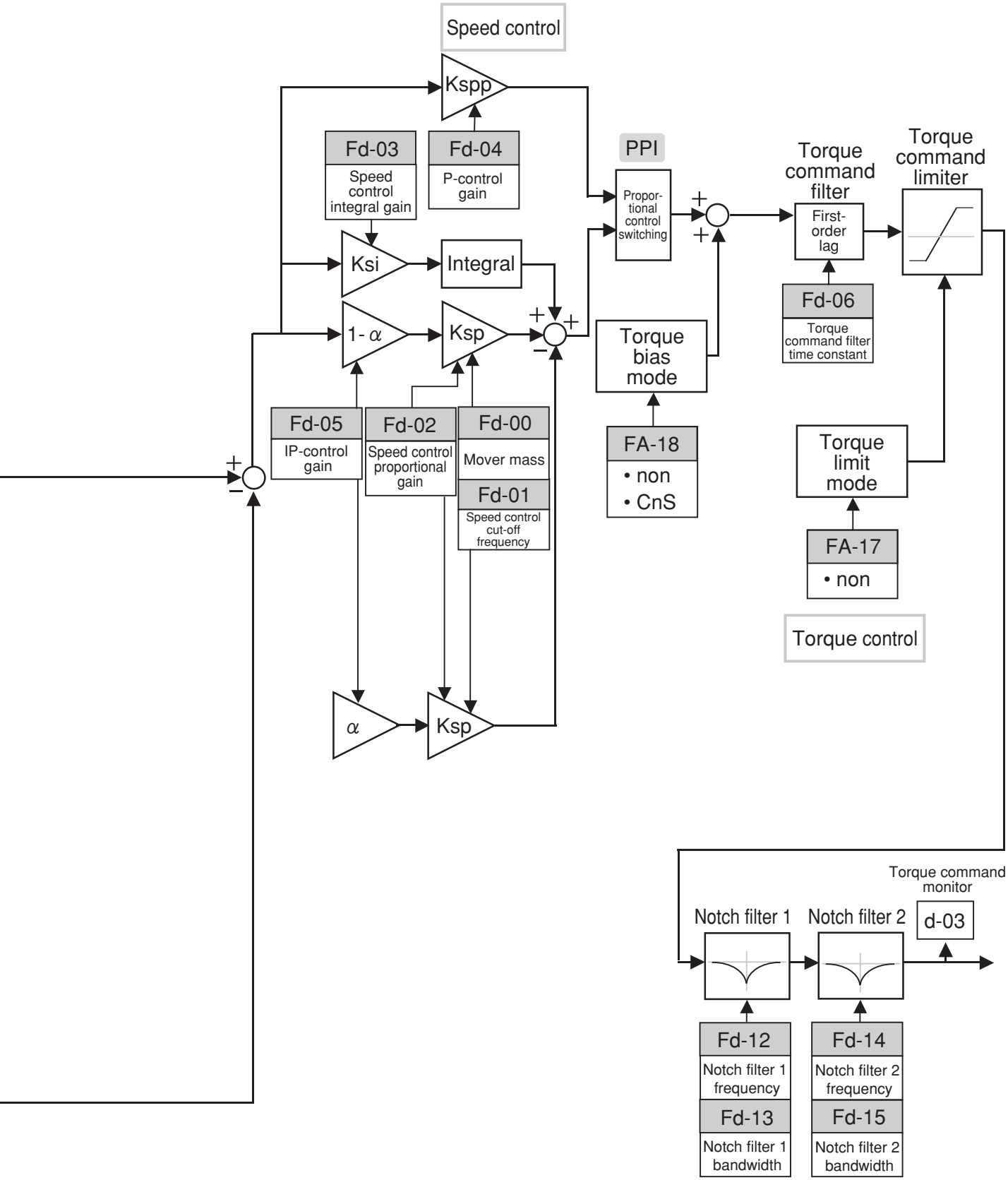
Payload [kg]	Acceleration [G]	Fd-09 [Hz]
0.0	1.88	12.0
25.0	0.82	6.6
50.0	0.47	4.5
75.0	0.33	4.5



6.4 Control block diagram and monitors

The following is the control block diagram for the robot driver, showing the relation among parameters, input terminals, and monitors.




Speed control
Kspp
Fd-03
Speed control integral gain
Fd-04
P-control gain
PPI
Propor-tional control switching
Torque command filter
First-order lag
Torque command limiter
Fd-06
Torque command filter time constant
Ksi
Integral
1- α
Ksp
Torque bias mode
FA-18
• non
• CnS
Fd-05
IP-control gain
Fd-02
Speed control proportional gain
Fd-00
Mover mass
Fd-01
Speed control cut-off frequency
Torque limit mode
FA-17
• non
Torque control
α
Ksp
Torque command monitor
Notch filter 1
Notch filter 2
d-03
Fd-12
Notch filter 1 frequency
Fd-13
Notch filter 1 bandwidth
Fd-14
Notch filter 2 frequency
Fd-15
Notch filter 2 bandwidth

MEMO

Chapter 7 Maintenance and Inspection

This chapter explains precautions and procedures for maintaining and inspecting this product.

Contents

7.1 Maintenance and inspection 7-1

7.1.1 Precautions for maintenance and inspection 7-2
7.1.2 Daily inspection 7-2
7.1.3 Cleaning 7-2
7.1.4 Periodic inspection 7-2

7.2 Daily inspection and periodic inspection 7-3

7.3 Megger test and breakdown voltage test 7-4

7.4 Checking the inverter and converter 7-4

7.5 Capacitor life curve 7-6

7.1 Maintenance and inspection

DANGER

AFTER TURNING POWER OFF, WAIT AT LEAST 10 MINUTES BEFORE STARTING MAINTENANCE AND MAKE SURE THE CHARGE LAMP ON THE DIGITAL OPERATOR PANEL IS OFF.
FAILURE TO DO SO MAY CAUSE ELECTRICAL SHOCK.

CAUTION

The capacitance of the capacitor on the power supply line drops due to deterioration.Replacing the capacitor based on its service life curve is recommended in order to prevent secondary damage resulting from capacitor failure. (See section 7.5 in this chapter.)
Using a deteriorated or defective capacitor may cause malfunction.

PROHIBITED

DO NOT ATTEMPT TO DISASSEMBLE OR REPAIR THE UNIT OR REPLACE ANY PARTS OF THE UNIT. ONLY QUALIFIED SERVICE PERSONNEL ARE ALLOWED TO DO REPAIR WORK.

7.1.1 Precautions for maintenance and inspection

(1)After turning power off, wait at least 10 minutes before starting maintenance and make sure the charge lamp on the digital operator panel is off.

(2)Do not attempt to disassemble or repair the unit.

(3)Do not perform a megger test or voltage breakdown test on the robot driver.

7.1.2 Daily inspection

- Check for any abnormal conditions or operation such as listed below:
  1. Check if the robot operates correctly according to the settings.
  2. Check if the environment where the unit is installed conforms to the specifications.
  3. Check the cooling system for abnormal conditions. (Control box, air filters, cooling fans, etc.)
  4. Check for abnormal vibration or noise.
  5. Check for overheating or discoloration.
  6. Check for unusual odors.

- Check the input voltage to the robot driver with a voltmeter during operation.
  1. Check if power supply voltage fluctuates frequently.
  2. Check if the line voltage is balanced.

7.1.3 Cleaning

- Always operate the robot driver in a clean condition.
- To clean the unit, wipe it gently with a soft cloth moistened with neutral detergent.

Note: Solvents such as acetone, benzene, toluene and alcohol can dissolve the robot driver surface or peel the paint. Do not use such solvents. Using detergent or alcohol might damage the display panel on the digital operator. Do not use them to clean the display panel.

7.1.4 Periodic inspection

- Check the following points or sections that cannot be inspected during operation or that require periodic inspection.
  1. Check the cooling system for abnormal conditions. ... Check the fan for operation.
  2. Check the screws for tightness and retighten if necessary. ... The screws and bolts might loosen due to vibration or temperature changes. Carefully check that they are securely tightened.
  3. Check the conductors and insulators for corrosion or damage.
  4. Measure the insulation resistance.
  5. Check the cooling fan and replace if necessary.

7.2 Daily inspection and periodic inspection

Check point	Check item	Check item	Check interval			Check method	Criteria	Instrument
			Daily	Regular 1 year	Regular 2 years			
General	Ambient environment	Check ambient temperature, humidity, dust.	O			Refer to Chapter 3, "Installation and Wiring".	Ambient temperature should be 0°C or more without freezing. Ambient humidity should be 90% or less without condensation.	Thermometer, hygrometer, recorder
	Overall equipment	Check for abnormal vibration or noise.	O			Visual and aural inspection	No abnormalities.	
	Power supply voltage	Check the main and control power circuit voltage.	O			Measure the voltage between L1, L2 and L3 on the robot driver main circuit, and between L1C and L2C on the control circuit.	Voltage should be within the specified AC voltage.	Tester and digital multimeter
Main circuit	General	(1) Check connections for tightness. (2) Check for evidence of overheating in various components. (3) Cleaning Note: Do not perform a megger test.		O O O		(1) Retighten. (2) Visual inspection	(1)(2) No abnormalities.	
	Connection conductors and cables	(1) Check the conductors for deformation. (2) Check the cable sheath for wear or damage.		O O		(1)(2) Visual inspection	(1)(2) No abnormalities.	
	Terminal block	Check the terminal block for damage.		O		Visual inspection	No abnormalities.	
	Inverter, converter	Check resistance between terminals.			O	Disconnect the cables from the robot driver and measure the resistance between terminals L1, L2 or L3 and (+) or (–), and between U, V or W and (+) or (–) with a tester or multimeter of ×1 Ω range.	Refer to the procedure described in 7.4, "Checking the converter and inverter", in this chapter. Typical inverter replacement interval: 10^6 start/stop cycles.	Analog tester or multimeter
	Smoothing capacitor	(1) Check for liquid leakage. (2) Check for bulging.	O O			(1)(2) Visual inspection (Check for evidence of liquid leakage and deformation of the case.)	(1)(2) No abnormalities. Typical replacement intervals: 5 years (See capacitor life curve.)	
	Relay	Check for chattering noise at on/off.		O		Aural inspection	No abnormalities.	
	Braking resistor	Check for wire breakage.		O		Remove the shorting bar or wire from control power connectors B1-B2 (200V class), and measure the resistance with a tester or multimeter.	Error should be within ±10% of specified resistance value.	Tester or digital multimeter
Indicator	Indicator	(1) Check if the 7-segment LED and charge lamp light up correctly. (2) Cleaning	O O			(1) Visual inspection (2) Clean with wiping cloth.	(1) Check if the LED and lamp light up correctly.	

Note 1: The capacitor life is affected by ambient temperature. Refer to 7.5, "Capacitor life curve", as a general guide for replacement.

Note 2: Refer to the robot user's manual for information regarding the robot.

7.3 Megger test and breakdown voltage test

Do not perform a megger test or voltage breakdown test. Semiconductor devices used in the inverter main circuit may deteriorate if subjected to such a test.

7.4 Checking the inverter and converter

- Use a tester or multimeter to check whether the module will operate correctly.

[Preparation]

1. Disconnect the externally connected power cables (L1, L2, L3, L1C, L2C), motor connection cables (U, V, W), regenerative braking resistor (+) and RB, and external DC power supply cables (+) and (–).
2. Prepare an analog tester or multimeter. (Use the 1-ohm resistance measurement range.)

[Check method]

Measure the continuity at L1, L2, L3, U, V, W, RB, (+), and (–) on the robot driver terminal block by alternately changing the polarity on the tester to determine if module operation is satisfactory.

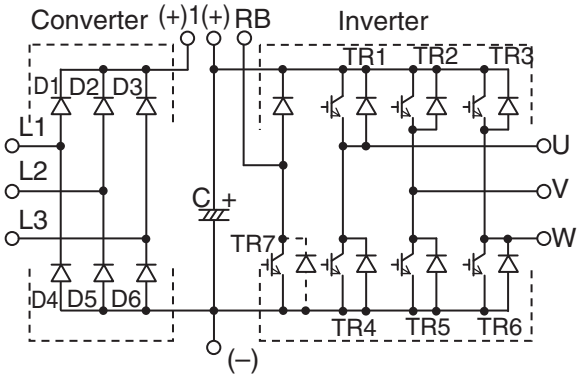
Note 1: First, measure the voltage across the (+) and (–) terminals on the terminal block of the robot driver by using the DC voltage range on the multimeter to make sure the smoothing capacitor is fully discharged. Then switch the multimeter to measure resistance and start making the checks.

Note 2: In the non-conducting state, the reading should be nearly infinite. However, the reading might not be infinite due to momentary conduction caused by effects of the smoothing capacitor. In a conducting state, the reading is usually several to several dozen ohms.
The reading might not always be the same depending on the device type and tester. However, the reading is satisfactory if equal to other values.

Note 3: Remove the cables from (+) and (–) on the main circuit terminal block (all models) and also remove the shorting bar or wire connected across terminals B1 and B2.

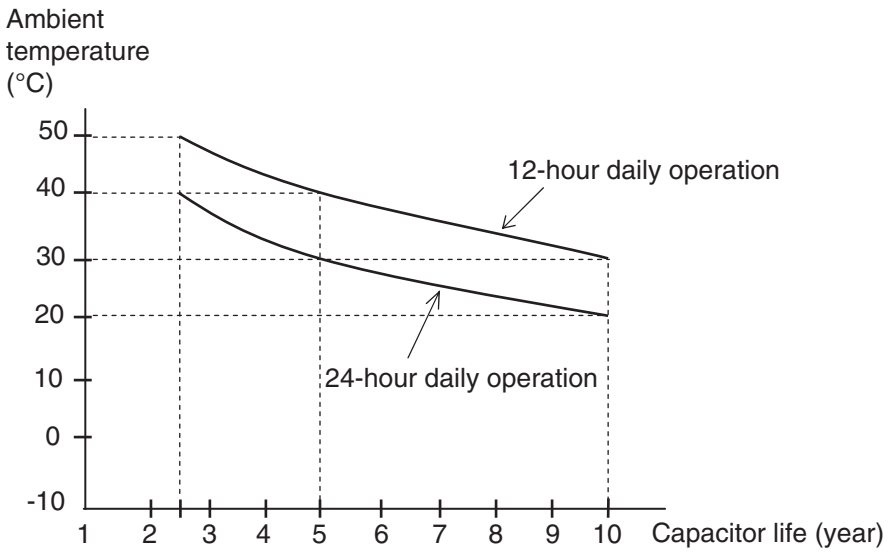
Note 4: The robot driver has an internal DB circuit between the main circuit terminals U and W, so the reading measured across the main circuit terminals is different from those shown in the table.

		Tester polarity *1		Reading
		⊕ (red)	⊖ (black)	
Converter	D1	L1	(+)1	Non-conducting
		(+)1	L1	Conducting
	D2	L2	(+)1	Non-conducting
		(+)1	L2	Conducting
	D3	L3	(+)1	Non-conducting
		(+)1	L3	Conducting
	D4	L1	(–)	Conducting
		(–)	L1	Non-conducting
	D5	L2	(–)	Conducting
		(–)	L2	Non-conducting
	D6	L3	(–)	Conducting
		(–)	L3	Non-conducting
Inverter	TR1	U	(+)	Non-conducting
		(+)	U	Conducting
	TR2	V	(+)	Non-conducting
		(+)	V	Conducting
	TR3	W	(+)	Non-conducting
		(+)	W	Conducting
	TR4	U	(–)	Conducting
		(–)	U	Non-conducting
	TR5	V	(–)	Conducting
		(–)	V	Non-conducting
	TR6	W	(–)	Conducting
		(–)	W	Non-conducting
BR section	TR7	RB	(+)	Non-conducting
		(+)	RB	Conducting
		RB	(–)	Non-conducting
		(–)	RB	Non-conducting



*1: Tester polarity may have to be reversed depending on the tester or multimeter type.

7.5 Capacitor life curve



Note 1: Ambient temperature is the temperature around the robot driver. When the robot driver is housed in a box, it is the temperature in the box.

Note 2: The smoothing capacitor wears out due to internal chemical reaction and should usually be replaced at 5 year intervals. Note, however, that the capacitor life will shorten drastically if the ambient temperature of the robot driver is high.

Note 3: Replacing the smoothing capacitor is not easy due to the robot driver structure. If servicing is needed, please contact our sales office or sales representative.

Chapter 8 Specifications and Dimensions

This chapter explains the specifications and dimensions of this product.

Contents

8.1 Specification tables 8-1

8.1.1 RDP specification table 8-1

8.1.2 RDX specification table 8-2

8.2 Robot driver dimensions and mounting holes 8-3

8.1 Specification tables

8.1.1 RDP specification table

Item \ Robot driver		RDP-05	RDP-10	RDP-20	RDP-25
Basic specifications	Applicable motor specifications	200V, 100W or less	200V, 200W or less	200V, 400W or less	200V, 750W or less
	Power supply capacity (KVA)	0.3	0.5	0.9	1.3
	Input power supply (main circuit)	Three-phase 200 to 230V AC +10%, –15%, 50/60Hz ± 5%			
	Input power supply (control circuit)	Single-phase 200 to 230V AC +10%, –15%, 50/60Hz ± 5%			
	Maximum speed (min/s) (Note 6)	3.0			
	Protective structure (Note 3)	Open type (IP00)			
	Control system	Sine-wave PWM (pulse width modulation)			
	Control mode	Position control			
	Position detection method	Magnetic linear scale			
Input/output functions	Position command input	Line driver signal (2M pulses/s or less) (1) Forward pulse + reverse pulse (2) Sign pulse + Command pulse (3) 90-degree phase difference 2-phase pulse command (maximum frequency: 500k pulses/s.) One of (1) to (3) is selectable.			
	Input signal	24V DC contact point signal input (usable for sink/source) (24V DC power supply incorporated) (1) Servo ON (2) Alarm reset (3) Torque limit (4) Forward overtravel (5) Reverse overtravel (6) Origin sensor (Note 5) (7) Return-to-origin (8)Pulse train input enable (9) Deviation counter clear			
	Output signal	Open collector signal output (usable for sink/source) (1) Servo ready (2) Alarm (3) Positioning complete			
	Position sensor monitor signal output	Phase A, B signal output: Line driver signal output Phase Z signal output: Line driver signal output / open collector signal output N/8192 (N=1 to 8191), 1/N (N=1 to 64) or 2/N (N=3 to 64)			
	Monitor output	Selectable items: 2 ch, 0 to ±3V voltage output, speed detection value, torque command, etc.			
Internal functions	Built-in operator	5-digit number indicator, key input × 5			
	External operator	Connectable to PC running on Windows 95/98/Me, Windows NT/2000/XP (via RS-232C port)			
	Regenerative braking circuit	Built-in (without a braking resistor)		Built-in	
	Dynamic brake (Note 4)	Built-in (operating condition settable) (without DB resistor, wiring: 2-phase short circuit)			Built-in (operating condition settable) (with DB resistor, wiring: 2-phase short circuit)
	Protective function	Overcurrent, overload, braking resistor overload, main circuit overvoltage, memory error, main circuit undervoltage, CT error, CPU error 1, ground fault detection at servo ON, control circuit undervoltage, robot driver temperature error, CPU error 2, overtravel error, PM error, resolver error, mismatch error, position deviation error, speed deviation error, overspeed error, drive range error, position monitor timeout error, magnetic pole position estimation error, magnetic pole position estimation incomplete			
Environment	Ambient temperature/ storage temperature (Note 1)	0 to +40°C / –10 to +70°C			
	Humidity	20 to 90% RH or less (no condensation)			
	Vibration (Note 2)	5.9m/s^2 (0.6G) 10 to 55Hz			
	Installation location	1000 meters or less above sea level, indoor place (free from corrosive gas and dust)			
	Approximate mass (kg)	0.8		1.0	1.4

Note 1: Storage temperature is the short-term temperature during transport.

Note 2: Conforms to JIS C0040 testing method.

Note 3: Protective system conforms to JEM1030.

Note 4: Use the dynamic brake only for emergency stop. Braking effect might be small depending on robot type.

Note 5: As the origin sensor, GX-F8B (made by SUNX) or FL7M-1P5B6-Z (made by YAMATAKE) is used. Origin sensor current consumption is 15mA or less (at open output) and only 1 origin sensor is connected to 1 robot driver.

Note 6: Calculated from parameters for controlling robot driver. This is not the maximum speed that the robot will move.

8.1.2 RDX specification table

Item \ Robot driver		RDX-05	RDX-10	RDX-20
Basic specifications	Applicable motor specifications	200V, 100W or less	200V, 200W or less	200V, 400W or less
	Power supply capacity (KVA)	0.3	0.5	0.9
	Input power supply (main circuit)	Three-phase 200 to 230V AC +10%, –15%, 50/60Hz ± 5%		
	Input power supply (control circuit)	Single-phase 200 to 230V AC +10%, –15%, 50/60Hz ± 5%		
	Brake power input	24V DC ± 10%		
	Maximum speed (min^{-1})	5000		
	Protective structure (Note 3)	Open type (IP00)		
	Control system	Sine-wave PWM (pulse width modulation)		
	Control mode	Position control		
	Position detection method	Resolver		
Input/output functions	Position command input	Line driver signal (2M pulses/s or less) (1) Forward pulse + reverse pulse (2) Sign pulse + Command pulse (3) 90-degree phase difference 2-phase pulse command (maximum frequency: 500k pulses/s.) One of (1) to (3) is selectable.		
	Input signal	24V DC contact point signal input (usable for sink/source) (24V DC power supply incorporated) (1) Servo ON (2) Alarm reset (3) Torque limit (4) Forward overtravel (5) Reverse overtravel (6) Origin sensor (Note 5) (7) Return-to-origin (8)Pulse train input enable (9) Deviation counter clear		
	Output signal	Open collector signal output (usable for sink/source) (1) Servo ready (2) Alarm (3) Positioning complete		
	Relay output signal	Brake release signal (24V, 375mA)		
	Position sensor monitor signal output	Phase A, B signal output: Line driver signal output Phase Z signal output: Line driver signal output / open collector signal output N/8192 (N=1 to 8191), 1/N (N=1 to 64) or 2/N (N=3 to 64)		
	Monitor output	Selectable items: 2ch, 0 to ±3V voltage output, speed detection value, torque command, etc.		
Internal functions	Built-in operator	5-digit number indicator, key input × 5		
	External operator	Connectable to PC running on Windows 95/98/Me, Windows NT/2000/XP (via RS-232C port)		
	Regenerative braking circuit	Built-in (without a braking resistor)		Built-in
	Dynamic brake (Note 4)	Built-in (operating condition settable) (without DB resistor, wiring: 2-phase short circuit)		
	Protective function	Overcurrent, overload, braking resistor overload, main circuit overvoltage, memory error, main circuit undervoltage, CT error, CPU error 1, ground fault detection at servo ON, control circuit undervoltage, robot driver temperature error, CPU error 2, overtravel error, PM error, resolver error, mismatch error, position deviation error, speed deviation error, overspeed error, drive range error, position monitor timeout error, origin sensor error		
Environment	Ambient temperature/ storage temperature (Note 1)	0 to +40°C / –10 to +70°C		
	Humidity	20 to 90% RH or less (no condensation)		
	Vibration (Note 2)	5.9m/s^2 (0.6G) 10 to 55Hz		
	Installation location	1000 meters or less above sea level, indoor place (free from corrosive gas and dust)		
	Approximate mass (kg)	0.8		1.0

Note 1: Storage temperature is the short-term temperature during transport.

Note 2: Conforms to JIS C0040 testing method.

Note 3: Protective system conforms to JEM1030.

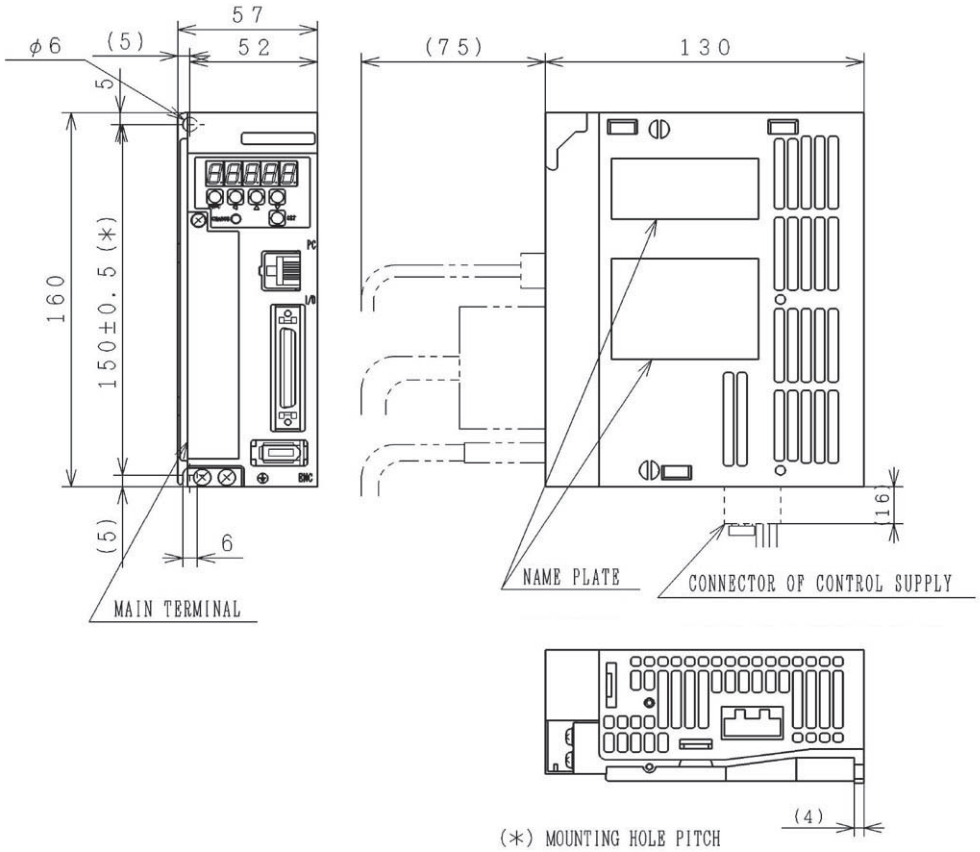
Note 4: Use the dynamic brake only for emergency stop.

Note 5: As the origin sensor, GX-F8B (made by SUNX) or FL7M-1P5B6-Z (made by YAMATAKE) is used. Origin sensor current consumption is 15mA or less (at open output) and only 1 origin sensor is connected to 1 robot driver. (Future specifications)

8.2 Robot driver dimensions and mounting holes

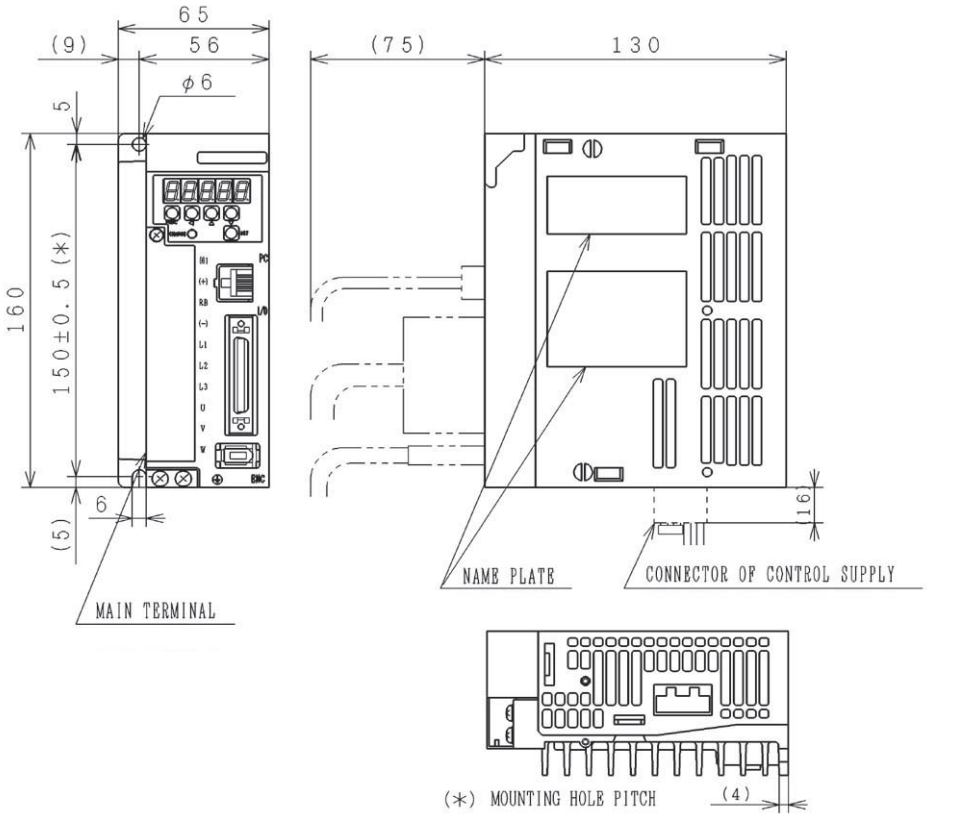
Model name	Model No.	Drawing
RDP (For PHASER series)	RDP-05	Fig. 1
	RDP-10	Fig. 1
	RDP-20	Fig. 2
	RDP-25	Fig. 3
RDX (For FLIP-X series)	RDX-05	Fig. 1
	RDX-10	Fig. 1
	RDX-20	Fig. 2

Fig. 1



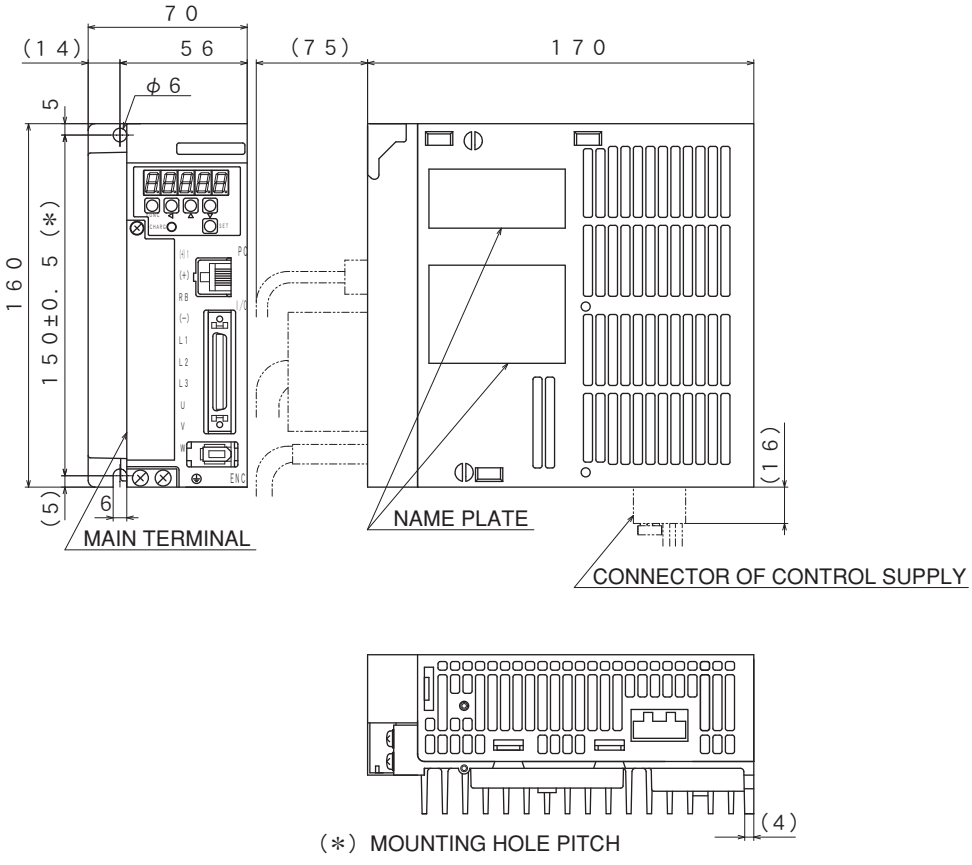
DIMENSION in mm

Fig. 2



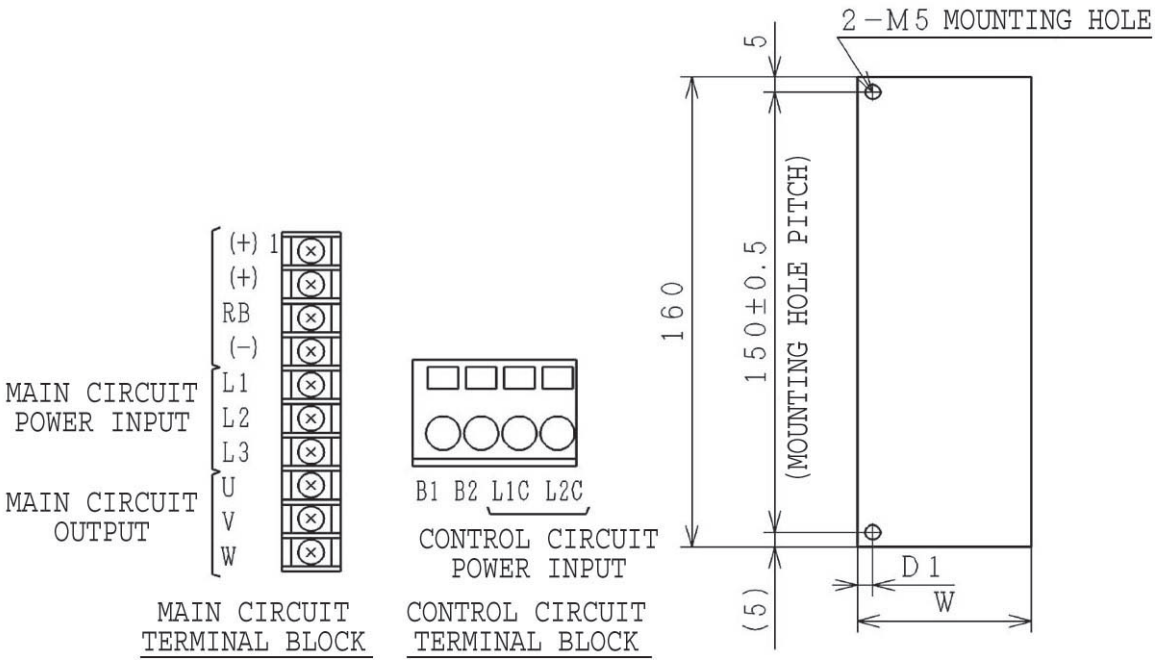
DIMENSION in mm

Fig. 3



DIMENSION in mm

Terminal block and mounting hole drawing



Output	W	D1
100W 200W	57	5
400W	65	9
750W	70	14

MEMO

Chapter 9 Troubleshooting

This chapter explains the protective functions, alarm display, and troubleshooting of this product.

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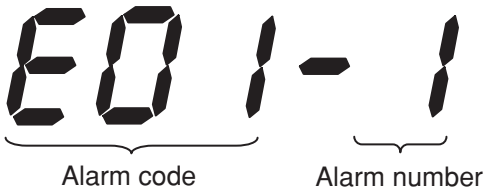
9.1 Alarm display (alarm log)

If an alarm has tripped, a display like that shown below appears.
The trip log monitor d-12 also shows the same information.



Display	Description
Alarm code (error number)	See section 9.2 in this chapter.
Alarm number	1 to 4: Number "1" is the latest alarm. A total of four alarms are saved in the memory.

The following information is displayed by pressing the ◁ key.

Information	Description
Speed command value	Speed command value when alarm tripped
Speed detection value	Speed detection value when alarm tripped (decimal display)
Output current value	Output current value when alarm tripped
DC voltage value between (+) and (–)	DC bus voltage between (+) and (–) when alarm tripped
Input terminal information	See the description of d-05.
Output terminal information	See the description of d-06.

The above example shows that an overcurrent alarm has tripped or the latest alarm log is an overcurrent.

9.2 Protective function list

The table below shows alarms and errors that might occur to protect the robot driver and robot.

No.	Alarm name	Alarm code	Description (cause of error)
1	Overcurrent	E01	Motor current higher than the specified value
2	Overload	E05	Overload current for longer than the specified time
3	Braking resistor overload	E06	The duty ratio of internal regenerative braking resistor exceeded the specified duty ratio (FA-08).
4	Main power overvoltage	E07	Main circuit DC bus voltage exceeded the specified value.
5	Memory error	E08	A check sum error occurred in the internal EEPROM of the robot driver due to external noise or abnormal temperature rise.
6	Main power undervoltage	E09	Main circuit DC bus voltage dropped below the specified value during servo-on.
7	CT error	E10	An abnormal offset value or out-of-range output value appeared in current detection CT output during servo-off.
8	CPU error 1	E11	A CPU watchdog error occurred.
9	Ground fault	E14	A motor output ground fault occurred when the servo was switched from OFF to ON.
10	Control power undervoltage	E20	The servo was turned off due to the control power supply voltage dropping below the specified value and the power then recovered before internal reset.
11	Abnormal temperature	E21	Power module temperature in the robot driver increased to abnormal levels.
12	CPU error 2	E22	A communication error with the CPU.
13	Overtravel error	E25	Both FOT and ROT were simultaneously enabled for 1 second or more during servo-on.
14	Power module error (Note 1)	E31	Overcurrent was detected by the power module, or power supply voltage for the base circuit dropped.
15	Position sensor signal error	E39	The following error was detected during constant monitoring. RDX: An error was detected by the ERR signal for the R/D converter. RDP: An error was detected by the wire breakage detection circuit signal for the resolver. Or, in the case of the RDP, an error occurred due to wire breakage detected by the "position sensor wire breaking detection" function which works when FA-90 (Hall sensor connection) is set to "oFF2".
16	Motor power mismatch	E40	Motor output or supply voltage does not match the robot driver. This error cannot be cleared from the RS (alarm reset) terminal.
17	Position error fault	E83	The difference between the position command value and the position detection value is larger than the "Position error detection value" (FA-05).
18	Speed error fault	E84	The difference between the speed command value and the speed detection value is larger than the "Speed error detection value" (FA-04).
19	Overspeed error	E85	Detection speed increased over the specified speed (maximum speed × FA-03).
20	Driving range error	E88	Position detection value was outside the specified range (Fb-16 to Fb-19).
21	Position monitoring timeout error	E89	Time required for the position error to enter positioning range after a position command value reached a certain position exceeded the "Positioning interval time limit" (Fb-24).
22	Magnetic pole position estimation error (Note 2)	E95	Magnetic pole position estimation failed.
23	Magnetic pole position estimation incomplete (Note 2)	E96	When in FA-90=oFF, the servo was turned on without performing any magnetic pole position estimation after power-on. When in FA-90=oFF, the SON terminal was turned on with the RS terminal turned on, in order to start mechanical system diagnosis or offline auto-tuning.
24	Origin sensor error	E80	After starting return-to-origin with the "Homing mode" (FA-23) set to "S-F" or "S-r" (sensor method) while the sensor (ORL terminal) was 0=ON, the ORL terminal did not turn off even when the robot moved a distance of 50,000 pulses or more.

Note 1: To clear the tripped alarm, shut off the power.
Note 2: Displayed on RDP only.

9.3 Troubleshooting

Corrective action for an alarm or error differs depending on whether the alarm or error has tripped or not. Each case is explained below.

9.3.1 When an alarm or error has not tripped

Symptom	Possible cause	Checkpoint	Action
Robot does not move.	Rated voltage was not applied to power supply terminals L1, L2, and L3, or L1C and L2C.	• Check the voltage with a tester. • Check the earth leakage breaker winding, electromagnetic contactor, etc. Also check if any alarm has tripped.	Correct failure or miswiring of the earth leakage breaker, electromagnetic contactor, etc., or clear the tripped alarm.
	Robot driver power input section is defective.	After checking the above, check if the charge lamp lights up.	If the charge lamp does not light up, the robot driver is defective. Replace or repair the robot driver.
	Miswiring or poor connection to robot	Check the phase sequence or contact failure.	Correct the phase sequence or misconnection.
	SON terminal is not ON. (Wrong polarity)	• Check if the SON terminal is ON, by viewing the input terminal monitor d-05. • Check the polarity setting.	• Turn on the SON terminal. • Correct the polarity setting.
	Torque limit is in effect. (Wrong polarity)	• Check if the TL terminal is ON, by viewing the input terminal monitor d-05. • Check if the setting is correct.	• Turn off the TL terminal. • Correct the polarity setting. • Correct the torque limit setting.
	FOT and ROT terminals are not ON. (Wrong polarity)	• Check if the FOT and ROT terminals are ON, by viewing the input terminal monitor d-05. • Check the polarity setting.	• Turn on the FOT and ROT terminals. • Correct the polarity setting.
	No pulse train command was input during position control mode. (Incorrect command format setting or wrong polarity)	• Check if the command is input, by viewing the Position command monitor d-07. • Check if the setting is correct. • Is the electronic gear ratio too low to see any robot movement? • Is the command position input pulse train rate is too low?	• Input the pulse train command. • Change the command format to match the input pulse train. • Set the electronic gear ratio correctly. • Increase the pulse rate.
	PEN terminal is not ON during position control mode. (Wrong polarity)	• Check if the PEN terminal is ON, by viewing the input terminal monitor d-05. • Check if the setting is correct.	• Turn on the PEN terminal. • Correct the polarity setting.
	Robot is locked. (Brake is activated.)	Check the lock.	Release the shaft.
	Servo was not turned on immediately after DB, before the robot speed dropped below 0.5% of the rated speed. (When using a robot driver of 5kW or more)	• Check if the servo was turned on immediately after DB. • Check if the robot speed was 0.5% or less of the rated speed when the servo was turned on.	Turn on the servo after the robot speed becomes 0.5% or less of the rated speed.
	Robot driver failure (Position sensor failure)	• Make sure this is not due to the above causes. • Check the power module. (Refer to Chapter 7, "Maintenance and Inspection".)	If the robot driver is defective, replace or repair it.

Symptom	Possible cause	Checkpoint	Action
Robot motion is unstable.	Large load variation	• Check the load variation. • Check the capacity calculation.	• Reduce the load variation. • Increase the capacity.
	Large backlash of the mechanical system	Check the backlash.	Reduce the backlash.
	Improper control gain	Check the parameter settings.	Readjust the control gain.
	Signal cable or position sensor cable intersects the main circuit cable. (These are in the same cable duct.)	Check the routing of the signal cable and position sensor cable.	Separate the signal cable and position sensor cable from the main circuit cable.
	Shield wire of the position sensor cable is not connected.	Check the shield wire connection on position sensor cable.	Connect the shield wire of the position sensor cable correctly.
	Robot driver failure (Position sensor failure)	• Check the power module. (Refer to Chapter 7, "Maintenance and Inspection".) • Check the position count function, by viewing the present position monitor d-08.	If the robot driver is defective, replace or repair it.
	Offline auto-tuning mode is set.	Check if the "Auto tuning mode" (FA-10) parameter is set to "non".	Set FA-10 to "non".
Robot speed does not increase.	Speed limit is applied.	• Check the parameter settings (Fb-20 and Fb-21).	Set the speed limit value correctly.
	Torque limit is in effect. (Wrong polarity)	• Check if the TL terminal is ON, by viewing the Input terminal monitor d-05. • Check if the setting is correct.	• Disconnect the TL terminal. • Correct the polarity setting. • Correct the torque limit setting.
	Incorrect command speed setting	Check the speed command input by viewing the Monitor d-00.	Correct the command setting.
	Improper control gain	Check if hunting occurs.	Readjust the control gain.
	Load is heavy.	• Check the load. • Check the calculated capacity.	• Reduce the load. • Increase the capacity.
	Brake is applied to the robot.	Check the brake.	Release the brake.

9.3.2 When an alarm or error has tripped

When an alarm or error has tripped, clear the alarm or error by inputting a reset signal through the RS terminal and take corrective action as shown in the following table. Then turn the servo on. (For clearing the tripped alarm, refer to the RS terminal description in section 5.2, "Input terminal functions".)

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E01	Overcurrent	• Output terminal is shorted. • Ground fault • Incorrect motor phase sequence	Check the cable connection.	Correct the cable connection.	A
		Sudden motor lock	Check the load.	Adjust the brake timing to avoid a lock.	
		• Power supply voltage is low. • Power supply fluctuates.	Check the power supply voltage. (Check the power supply capacity.)	Correct the power supply voltage, capacity, and wiring.	
		Position sensor failure	Check the count by viewing the present position monitor (d-08).	If defective, replace or repair it.	C
		Power (inverter) module is damaged.	Check the power module. (Refer to Chapter 7, "Maintenance and Inspection".)		A
		DB relay failure	Disconnect the motor cables from the robot driver and check the resistance between U, V and W, using an ohmmeter or multimeter.		
E05	Overload	Load is too heavy.	Check the load.	Reduce the load.	B
		Motor is locked.		Adjust the brake timing to avoid a lock.	C
		Incorrect robot phase sequence	Check the cable connection.	Correct the cable connection.	A
		Robot's position sensor failure	Check if the counter correctly works, by viewing the present position monitor d-08.	If the sensor is defective, replace or repair it.	C
E06	Braking resistor overload	Regenerative load is too heavy. Balance weight is so large that continuous regeneration is applied.	Check the regenerative load.	• Reduce the load. • Shorten the deceleration time.	A
		Insufficient regenerative capacity		Review the regenerative resistance.	
		Deceleration time is too short.	Check if an alarm tripped during deceleration.	Increase the deceleration time.	B
		Power supply voltage is high.	Check the power supply voltage.	Adjust the power supply voltage correctly.	A
		Regenerative braking operating ratio is set to a small value.	Check if the duty ratio matches the regenerative resistance.	Set a correct duty ratio.	B

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E07	Main power overvoltage	Regenerative resistance is large.	Check the regenerative resistance.	Reduce the regenerative resistance to the minimum (R_{BR}min). (Refer to (3) of section 3.2.2, "Main circuit wiring".	A
		Deceleration time is too short.	Check the deceleration time.	Increase the deceleration time.	C
		Robot was put into hunting and momentary regeneration occurred.	Check if the robot was placed in hunting (abnormal noise).	Adjust the position/speed control gain correctly.	
		Regenerative resistor is not connected, or is open or damaged.	Check the regenerative resistor connection or the regenerative resistance.	• Connect the regenerative resistor correctly. • Replace the regenerative resistor.	A
		Received power voltage is too high or a ground fault has occurred.	• Check the power supply voltage. • Check the connection.	• Reduce the voltage. • Correct the connection.	
E08	Memory error	Sum error in the internal EEPROM of robot driver	Check if all settings for the robot driver are correct.	• After clearing the tripped alarm, return the parameters to the factory settings, and then restart operation. • If defective, replace or repair it.	C
		An EEPROM write or read error was caused by noise.	• Check if any noise source exists near the robot driver. • Check if the set values are correct.	• Remove the noise source. • After clearing the tripped alarm, return the parameters to the factory settings, and then restart operation.	A

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E09	Main power undervoltage	Main circuit power supply voltage is low.	Check the power supply system.	Increase the power supply voltage.	C
		A unit in the power supply system is drawing a heavy current that lowers the voltage while that unit is operating.		Isolate the power supply system into separate units and the robot driver.	A
		Chattering occurs in the electromagnetic contactor on power supply side.		Replace the electromagnetic contactor.	
		Poor connection in power supply system		Repair the poor connection.	
		Insufficient power supply capacity		Provide larger power supply capacity.	
		Only control power supply is provided.		Connect wiring to the main circuit.	
		SON terminal turns on before the power voltage of the main circuit becomes stable.	Check the SON terminal input timing.	Turn on the SON terminal 1 second or longer after the main power has turned on.	
		• Main circuit power supply voltage is lowered. • A momentary power failure occurred.	Check if the symptom shown at left has occurred.	After clearing the tripped alarm, restart operation.	C
E10	CT error	• Current detector failure • Current detector malfunction caused by noise	Turn off and on the power supply again.	If the CT is defective, contact us for repair.	A
			Check if there is any noise source near the robot driver.	Isolate the noise source away from the robot driver.	
E11	CPU error 1	Microcomputer in robot driver is out of control due to noise.	Check if there is any noise source (including a solenoid coil and electromagnetic contactor) near the robot driver.	• Isolate the noise source away from the robot driver. • Install a noise filter or surge absorber.	A
			Turn off and on the power supply again and check the condition.	If the CPU is defective, contact us for repair.	
E14	Ground fault at servo-on	A ground fault occurred in the robot or between the robot and robot driver.	Disconnect the cables and check the ground fault point by megger test.	Correct the ground fault point.	A
		Robot driver is at fault.		Contact us for repair.	

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E20	Control power undervoltage	Control circuit power supply voltage is low.	Check the power supply system.	Increase the power supply voltage.	C
		A unit in the power supply system is drawing a heavy current that lowers the voltage while that unit is operating.		Isolate the power supply system into separate units and the robot driver.	A
		Chattering in electromagnetic contactor on power supply side		Replace the electromagnetic contactor.	
		Poor connection in power supply system		Repair the poor connection.	
		Insufficient power supply capacity		Provide larger power supply capacity.	
		Control circuit power supply voltage is lowered. A momentary power failure occurred.	Check if the symptom shown at left has occurred.	After clearing the tripped alarm, restart operation.	C
E21	Robot driver overheat	The load is too heavy.	Check the load. Check the ambient temperature.	• Clear the tripped alarm after the robot driver cools down, or lower the ambient temperature.	B or C
		Ambient temperature of robot driver is higher than 55°C.			
		Motor shaft is locked.	Visual check.	Unlock the motor.	A
		The duty ratio of the built-in regenerative braking resistor is high.	Check the regenerative capacity.	Use an external braking resistor.	
E22	CPU error 2	Microcomputer in robot driver cannot communicate due to noise.	Check if there is any noise source (including a solenoid coil and electromagnetic contactor) near the robot driver.	• Isolate the noise source away from the robot driver. • Install a noise filter or surge absorber.	A
		Problem in communication circuit	Turn off and on the power supply again and check the condition.	If the circuit is defective, contact us for repair.	
E25	Overtravel	Wrong terminal connection	Check the cable connection.	Correct the cable connection.	A
		FOT/ROT terminals were not ON (closed) at servo-on.	Check if the FOT/ROT terminals are ON, by viewing the Input terminal monitor d-05.	Turn on both or at least one terminal of the FOT and ROT terminals.	C

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E31	PM (power module) error	Output terminal is shorted. A ground fault has occurred. Robot phase sequence is incorrect.	Check the cable connection.	Correct the cable connection.	A
		Sudden motor lock	Check the load.	Adjust the brake timing to avoid a lock.	
		Power supply voltage is low. Power supply fluctuates.	Check the power supply voltage. (Check the power supply capacity.)	Correct the power supply voltage, capacity, and wiring.	
		Position sensor failure	Check if the count is correct by viewing the present position monitor (d-08).	If defective, contact us for repair.	
		Power (inverter) module is damaged.	Check the power module. (Refer to Chapter 7, "Maintenance and Inspection".)		
E39	Position sensor error	Wire breakage or poor connector mating of position sensor cable.	Check the cable, connector, shield wire, and ground wire.	Correct the wire breakage or connector mating.	A
		Inadequate cable shielding or ground wire.		Strengthen the shielding and grounding.	
		Position sensor cable is routed along power cable.		Isolate the position sensor cable away from the power cable.	
		Malfunction caused by noise	Check if there is any noise source nearby.	Isolate the noise source away from the robot driver.	
		Position sensor failure	While moving the motor shaft with servo turned off, check if the Current position counter (d-08) changes.	If the sensor is defective, contact us for repair.	
		Position sensor was not connected when power was turned on.	Check whether the sensor was connected before power-on.	Turn on the power while the position sensor is connected.	
E40	Mismatch error	Robot driver output does not match the robot.	Check the position sensor cable connection.	Connect the position sensor cable correctly and select a correct robot and robot driver combination.	A
		Voltage levels of robot and robot driver do not match.			
		Position sensor combination is wrong.	Check the parameters (FA-81, FA-82).	Correct the parameter settings.	
		Position sensor division ratio is wrong.	Check the parameters (FC-09, FC-10).	Correct the parameter settings.	
E80	Origin sensor error	Origin sensor is not operating correctly.	Check if the ORL terminal is ON by viewing the Input terminal monitor d-05.	• Turn on the ORL terminal. • Replace the origin sensor.	

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E83	Position deviation error	Pulse position command rate is too fast.	Check the position command input rate.	Lower the pulse position command rate.	C
		Electronic gear setting is incorrect.		Set the electronic gear correctly (reduce the ratio).	
		Control gain does not match.	Check the setting.	Adjust the control gain.	
		Speed or torque limiter is too low.		Set (increase) the speed or torque limiter correctly.	
		Position error detection level setting is too small.		Set (increase) the position error detection level correctly.	
		Malfunction caused by noise	• Check if there is any noise source nearby. • Check the routing of the cable, connectors, shield wire, and ground wire.	• Isolate the noise source away from the drive. • Strengthen the shielding and grounding. • Isolate the position sensor cable away from the power cable.	A
		Moment of load inertia is too heavy.	Check relation of load to position command rate.	Reduce the load.	
E84	Speed deviation error	Speed command input setting is incorrect.	Check the setting.	Correct the input setting.	C
		Control gain does not match.		Adjust the control gain.	
		Torque limiter is too low.		Correct (increase) the torque limiter.	
		Speed error detection level setting is too small.		Correct (increase) the speed error detection value.	
		Malfunction caused by noise	• Check if there is any noise source nearby. • Check the routing of the cable, connectors, shield wire, and ground wire.	• Isolate the noise source away from the drive. • Strengthen the shielding and grounding. • Isolate the position sensor cable away from the power cable.	A
		Moment of load inertia is too heavy.	Check relation of load to position command rate.	Reduce the load.	

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E85	Overspeed error	Speed command input setting is wrong.	Check the setting.	Correct the input setting.	C
		Control gain does not match.		Adjust the control gain.	
		Torque limiter is too low.		Correct (increase) the torque limiter correctly.	
		Overspeed error detection level setting is too low.		Set the overspeed error detection level correctly (increase).	
		Malfunction caused by noise	• Check if there is any noise source nearby. • Check the routing of the cable, connectors, shield wire, and ground wire.	• Isolate the noise source away from the drive. • Strengthen the shielding and grounding. • Isolate the position sensor cable away from the power cable.	A
		Moment of load inertia is too heavy.	Check if overshooting has occurred.	Reduce the load.	
		Wrong motor cable connection	Check the connection.	Correct the connection.	
		Position sensor failure	While rotating the motor shaft, check if the display on the present position monitor d-08 changes sequentially.	If the sensor is defective, contact us for repair.	C
E88	Drive range error	• Pulse train position command was mistakenly input. • Origin position is wrong. • Operated outside the drive range.	Check the master control unit.	After removing the cause of trouble, clear the tripped alarm and restart operation.	A
		Needs larger operating margin outside the drive range	Check if a load moved the robot near the drive range limit.	• Review the setting outside the drive range. • Adjust or remove the load so that it will not move the robot.	C
		Electronic gear setting is incorrect.	Check the control device.	Correct the setting.	
		Torque limiter is too low.			
		Control gain does not match.		Adjust the control gain.	

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Alarm No.	Alarm name	Possible cause	Checkpoint	Action	Reset
E89	Position monitoring timeout error	Control gain, Positioning detection range (Fb-23), or wrong positioning interval time-limit setting (Fb-24).	Check the setting.	Adjust each setting.	C
		Electronic gear setting is wrong.		Correct the setting.	
		Robot is locked.	Check the load.	• Unlock the robot. • Adjust the brake release timing.	
		Load is larger than the estimated level.		• Reduce the load. • Increase the robot and robot driver capacity.	A
		Torque limiter is in effect.	Check the TL terminal and setting.	• Disconnect the TL terminal. • Change the setting.	C
E95	Magnetic pole position estimation error	Related parameter settings are incorrect.	Check the parameter (FA-82, FA-85, FA-87, Fd-00) settings.	Correct the parameter settings.	A
		Parameter settings for magnetic pole position estimation (Fb-40 through Fb-43) are incorrect.	Torque during magnetic pole position estimation is small.	Adjust Fb-40 through Fb-43 to make the generated torque larger.	
			Torque during magnetic pole position estimation is limited.	Adjust Fb-40 through Fb-43 to eliminate the torque limit.	
		FOT and ROT terminals turn off during magnetic pole position estimation.	Check the FOT and ROT terminal conditions.	• Turn on the FOT and ROT terminals. • Change the FC-01 setting.	
		Rotor was moved by external force during magnetic pole position estimation.	Check if external force is applied.	• Remove the external force.	
		Position sensor failure	While rotating the motor shaft, check if the display on the present position monitor d-08 changes sequentially.	If the sensor is defective (display does not change), contact us for repair.	
		SON terminal and the FOT and ROT terminals turn on at the same time.	Check the input timing of the FOT, ROT, and SON terminals.	Turn on the SON terminal 10 [ms] or longer after the FOT and ROT terminals have turned on.	
E96	Magnetic pole position estimation incomplete	Any magnetic pole position estimation operation was not performed after power-on.	Check that the SRD terminal is ON.	Perform magnetic pole position estimation.	A
_ _Err	Auto-tuning error	Operation was performed in offline auto-tuning mode.	Check if FA-10 is set to "non".	Turn off the SON terminal, turn the RS terminal on and off, and then check that FA-10 is set to "non".	C
		Moment of load inertia exceeded 128 times.	Check the moment of load inertia.		

Letters in the Reset column:

A: Shut off the power to the robot driver, perform troubleshooting, replace or repair defective parts.

B: After the robot stops, wait until the robot driver cools. Then short RS to P24, and perform troubleshooting.

C: After the robot stops, short RS to P24, and perform troubleshooting or shut off the power.

Chapter 10 Appendix

This chapter explains the options for this product.

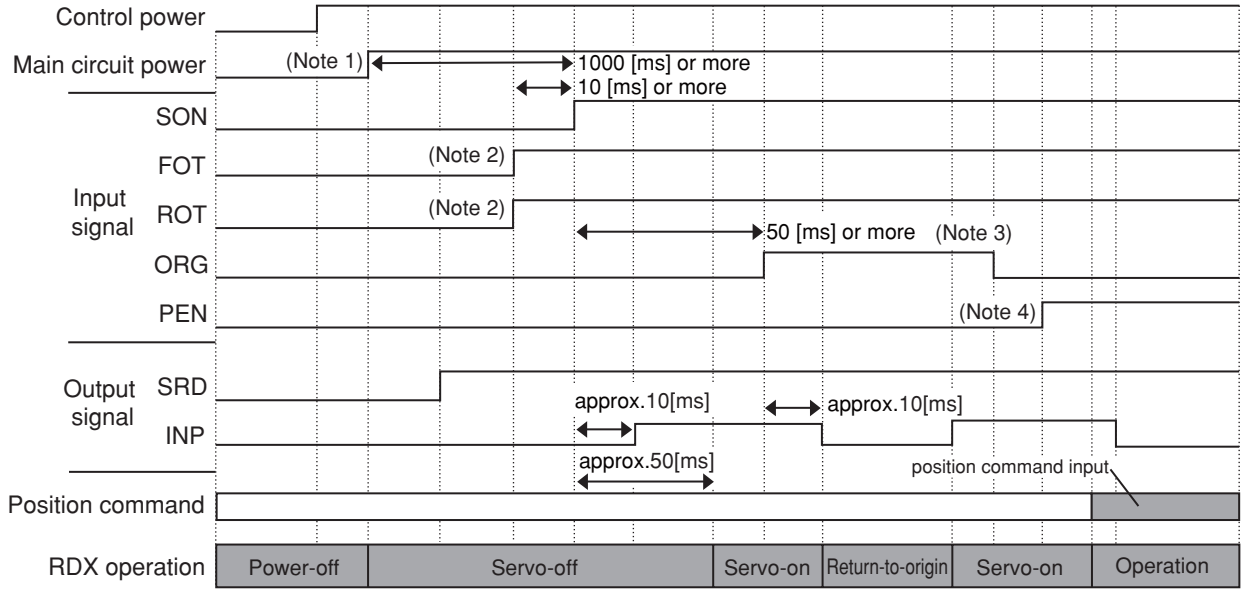
Contents

10.1 Timing chart 10-1
10.2 Options 10-2
10.3 Recommended peripheral devices 10-7
10.4 Internal block diagram of robot driver 10-13

10.1 Timing chart

The following shows the timing chart from the power-on to the position command input (when the return-to-origin is performed).

■ RDX



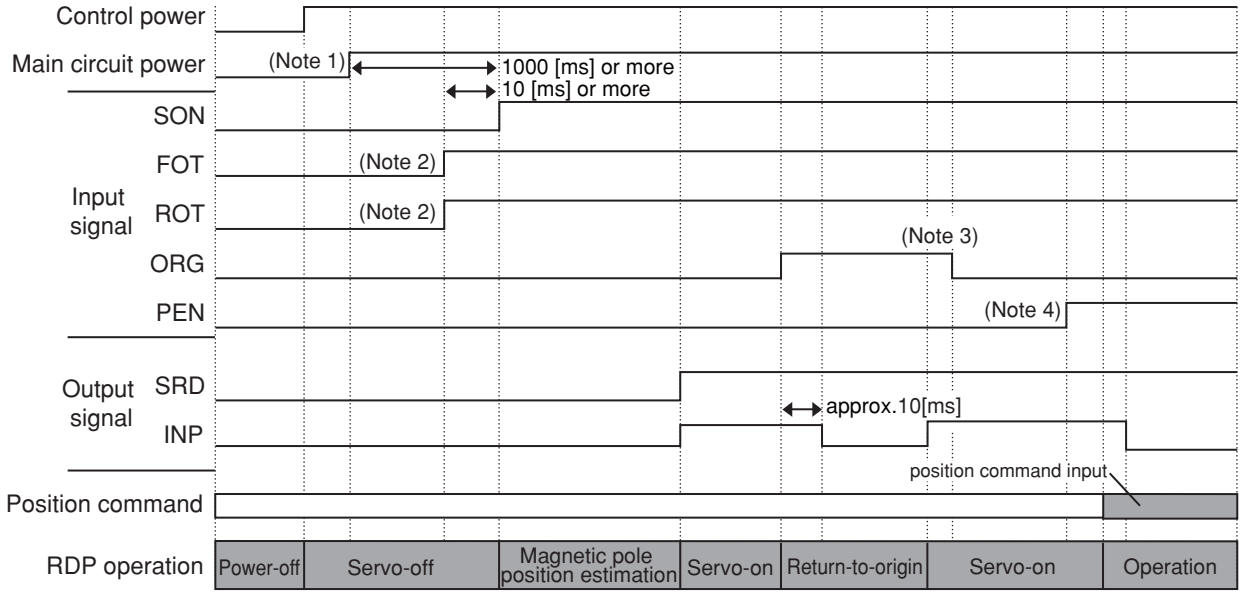
Note 1: Turn on the main circuit power after the control power has been turned on or at the same time when the control power is turned on.

Note 2: Turn on the FOT and ROT signals 10 [ms] or more before the SON signal is turned on.

Note 3: When the return-to-origin has been completed, the INP signal turns on. So, turn off the ORG signal after the INP signal has turned on.

Note 4: Turn on the PEN signal 10 [ms] or more before the position command is input.

■ RDP



Note 1: Turn on the main circuit power after the control power has been turned on or at the same time when the control power is turned on.

Note 2: Turn on the FOT and ROT signals 10 [ms] or more before the SON signal is turned on.

Note 3: When the return-to-origin has been completed, the INP signal turns on. So, turn off the ORG signal after the INP signal has turned on.

Note 4: Turn on the PEN signal 10 [ms] or more before the position command is input.

10.2 Options

(1)Dedicated software for YAMAHA RD series (TOP for Windows)

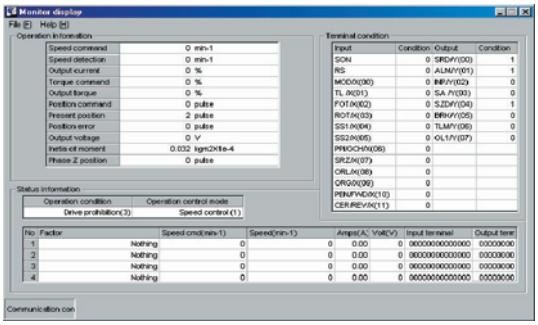
When the RD series robot driver is connected to a PC, the TOP software allows you to set parameters, monitor the position/speed/torque settings, and display graphics. The TOP software runs on Windows and offers user-friendly operation.

■ System requirements

Item	Condition
PC	IBM PC compatible computer Memory: 32MB or more Free hard disc space : 30MB or more Monitor resolution: 800 × 600 or higher recommended.
OS	Windows 95/98/Me, Windows NT, Windows 2000, Windows XP
PC cable	KBH-M538F-00

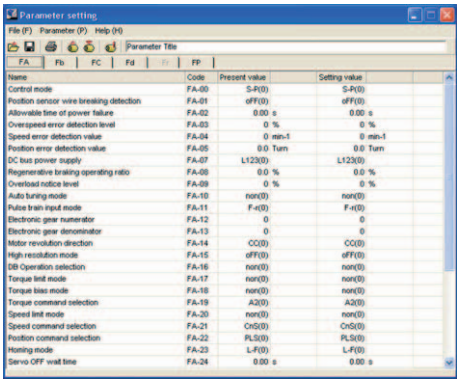
■ Monitoring function

Monitors operation information and terminal status in real time.



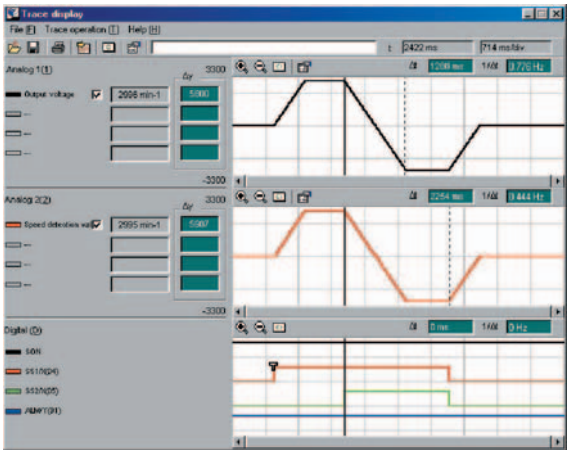
■ Parameter setting

Allows setting, saving and loading parameters from the PC.



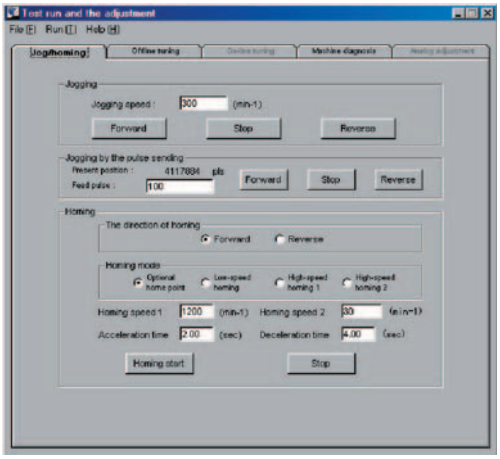
■ Operation trace function

This function graphically displays the robot speed and motor current, etc.



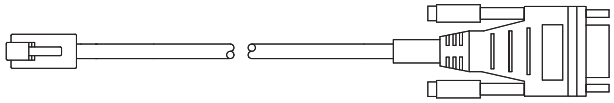
■ Test run and adjustment

Supports useful functions such as test run, jog operation and offline auto-tuning, etc.

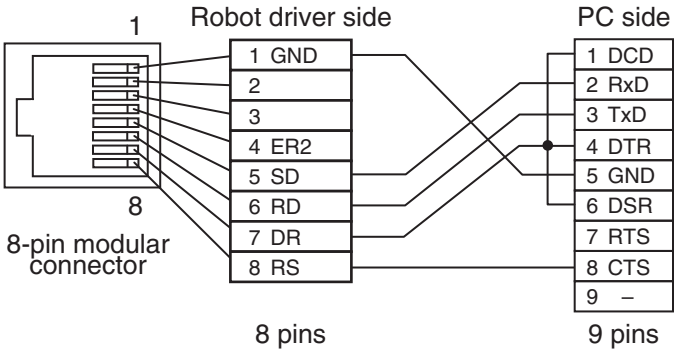


(2)Cables

■ PC cable

Length L	Description
2m	Robot driver side — PC side  Wiring and pin assignment are shown below. 8-pin modular connector — 9-pin D-Sub connector

Connection of PC cable



■ Connection to a PC with no serial port (RS-232C)

When running the TOP software on a PC with no RS-232C port and connecting the PC to the RD series robot driver, you may use the following PC card or USB-serial converter. Use these devices at your own risk.

< PC card >

Product name	PC Card Standard Type II RS-232C PC Card
Manufacturer	RATOC Systems
Type No.	REX-5056V
Accessory	9-pin D-sub (male) cable (50 cm)

< USB-serial converter >

Product name	USB Serial Converter
Manufacturer	RATOC Systems
Type No.	REX-USB60F
Connector	USB (type A)
OS	Windows XP, Windows 2000, Windows 98 SE

For detailed information, you can access RATOC Systems website: http://www.rexpccard.co.jp

Operation under different software usage conditions such as effects due to the installation environment at the site or different PC types has not been confirmed. Usage under such conditions is the responsibility of the customer.

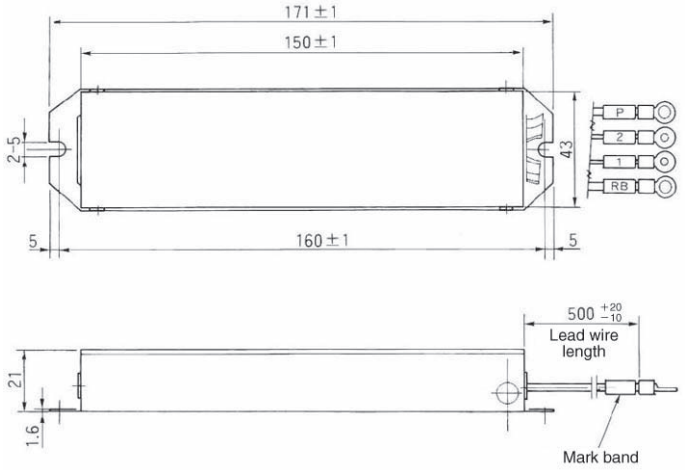
(3)Precautions for braking resistor

CAUTION

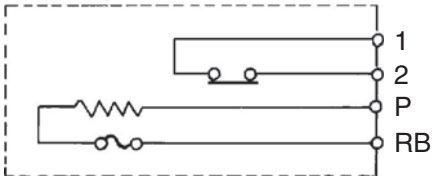
- Install the braking resistor on a noncombustible object, such as metal. Failure to do so may cause fire.
- Do not place the braking resistor close to a combustible object. Doing so may cause fire.
- Do not install the braking resistor in an ambient environment where the temperature is high, the humidity is high, or dew condensation occurs easily or a place where dust, corrosive gas, explosive gas, flammable gas, coolant mist, or salt damage exists. Always install the braking resistor in a well-ventilated indoor place where it is not exposed to the direct sunlight. Failure to do so may cause fire.
- The braking resistor generates heat by itself. So, install the braking resistor far away from the robot driver or cables.
  Additionally, carefully check the ventilation and dimensions so that the ambient temperature of the robot driver does not exceed its operating range. Failure to do so may cause fire.
- When installing the braking resistor in a place where it may be in contact with a human body, cover it with breathable protective metal fixtures so that it is not directly in contact with a human body. Failure to do so may cause personal injury.

(4)Braking resistor RBR1 (small type)

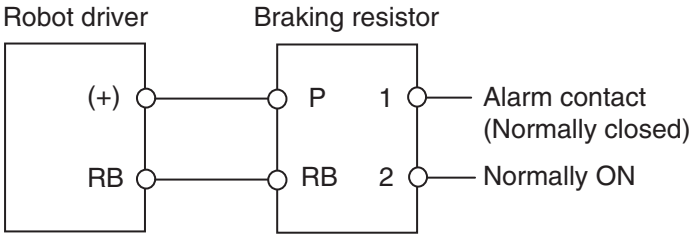
■ Dimensions (mm)



■ Circuit diagram



■ Connection diagram



Model No.	Rated wattage	Resistance	Allowable braking ratio (%ED)	Allowable continuous braking time	Mass (kg)
KBH-M5850-00	120W	100Ω	2.5% (1.5%)*	12 sec.	0.27
Error detection function	Internal thermal relay (contact capacity, AC 240V, 2A max, Normally ON (b-contact), internal thermal fuse (unrecoverable)				

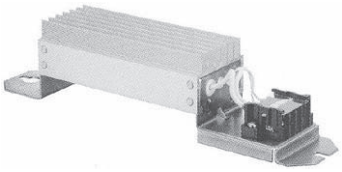
* : Value in ( ) indicates the allowable braking ratio for 400V class.

Note 1:Thermal relay and fuse are built into the braking resistor.

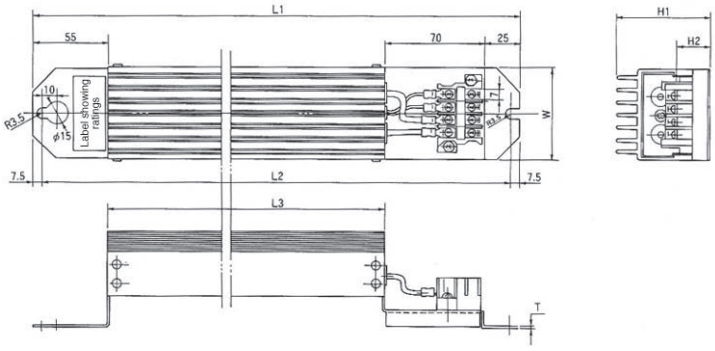
Note 2:Internal thermal fuse prevents excessive heat generation which may occur due to misoperation (unrecoverable).

Note 3:An appropriate safety circuit is configured so that the main power of the robot driver is turned off if the thermal relay is tripped (an alarm occurs).

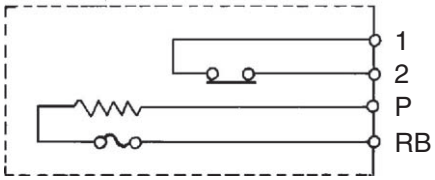
(5)Braking resistor RBR2 (standard type)



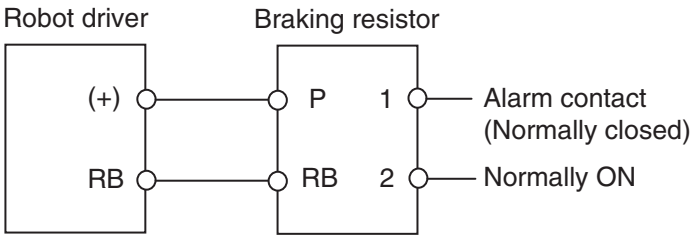
■ Dimensions (mm)



■ Circuit diagram



■ Connection diagram



Model No.	Dimensions (mm)							Mass (kg)
	L1	L2	L3	H1	H2	W	T	
KBH-M5850-10	310	295	160	67	12	64	1.6	0.97

Model No.	Rated wattage	Resistance	Allowable braking ratio (%ED)	Allowable continuous braking time
KBH-M5850-10	200W	100Ω	7.5% (3%)*	30 sec.
Error detection function	Internal thermal relay (contact capacity, AC 240V, 2A max, Normally ON (b-contact), internal thermal fuse (unrecoverable)			

* : Value in ( ) indicates the allowable braking ratio for 400V class.

Note 1:Thermal relay and fuse are built into the braking resistor.

Note 2:Internal thermal fuse prevents abnormal heat generation which may occur due to misoperation (unrecoverable).

Note 3:An appropriate safety circuit is configured so that the main power of the robot driver is turned off if the thermal relay is tripped (an alarm occurs).

10.3 Recommended peripheral devices

This section describes the recommended optional devices for the RD series robot drivers. All optional devices introduced here are manufactured by Hitachi Industrial Equipment Systems Co., Ltd.

(1) Input side AC reactor (for harmonic suppression, power coordination, power factor improvement)

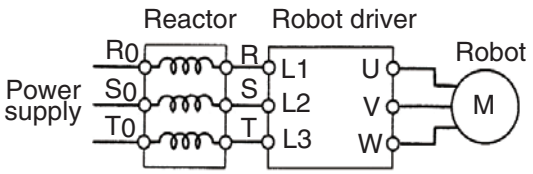
■ **Model No.**

ALI–2.5L

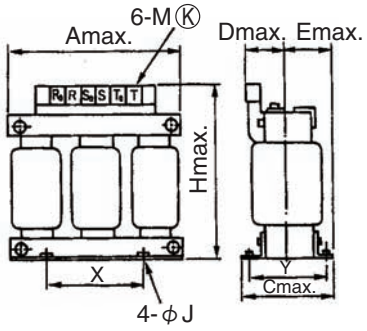
Capacity (See the table below for interrelation with robot driver.)

Input side AC reactor

■ **Connection diagram**



■ **Dimension drawing**



Robot driver model No.	Input side AC reactor model No.	Dimensions (mm)							J	K	Mass (kg)
		A	C	D	E	H	X	Y			
RD*-05	ALI-2.5L	130	82	60	40	150	50	67	6	4	2.4
RD*-10											
RD*-20											
RDP-25											

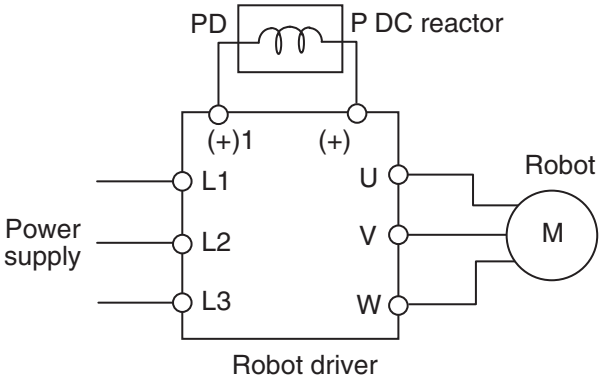
(2)DC reactor (for harmonic suppression, power coordination, power factor improvement)

■ Model No.

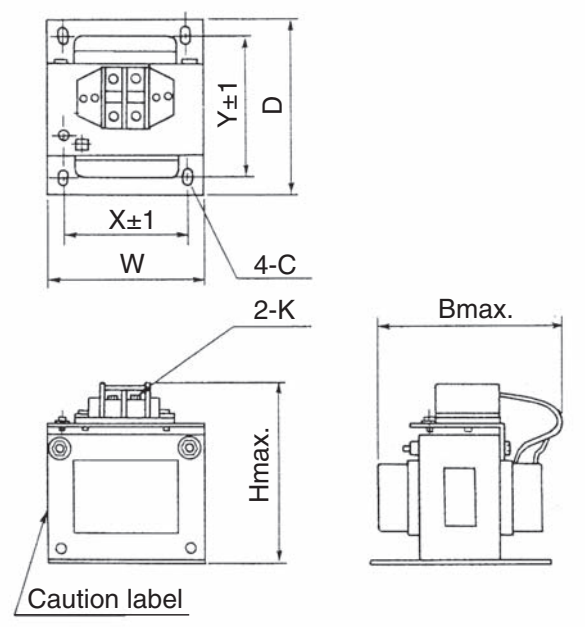
DCL-L-0.2

Capacity
(See the table below for interrelation with robot driver.)

■ Connection diagram



■ Dimensions (mm)



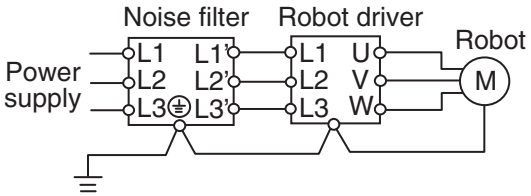
Robot driver model No.	DC reactor model No.	Dimensions (mm)								Mass (kg)
		W	D	H	B	X	Y	C	K	
RD*-05	DCL-L-0.2	66	90	98	85	56	72	5.2×8	M4	0.8
RD*-10	DCL-L-0.4	66	90	98	95	56	72	5.2×8	M4	1.0
RD*-20	DCL-L-0.7	66	90	98	105	56	72	5.2×8	M4	1.3
RDP-25	DCL-L-1.5	66	90	98	115	56	72	5.2×8	M4	1.6

(3)Input side noise filter

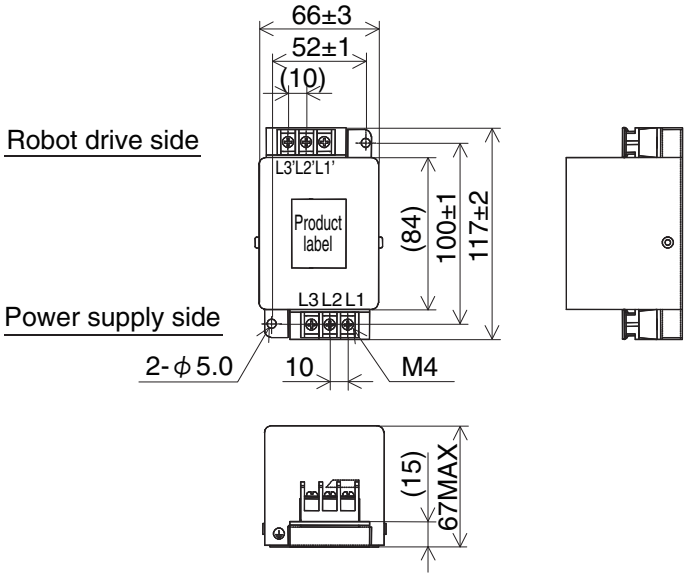
■ **Model No.**

NF-L 6
- 6: Rated current of noise filter
- NF-L: Series name (NF series)

■ **Connection diagram (3-phase product)**



■ **Dimensions (mm)**



■ **Specifications**

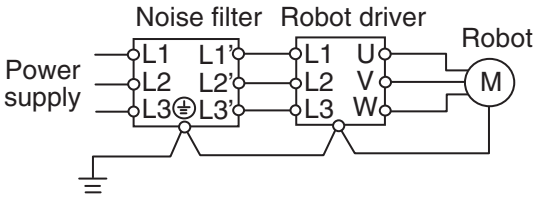
Robot driver model No.	Noise filter model No.	Rated voltage	Rated current	Mass (kg)
RD*-05	NF-L6	250V AC	6A	0.5
RD*-10				
RD*-20				
RDP-25				

(4)Input side noise filter (EMC compliance)

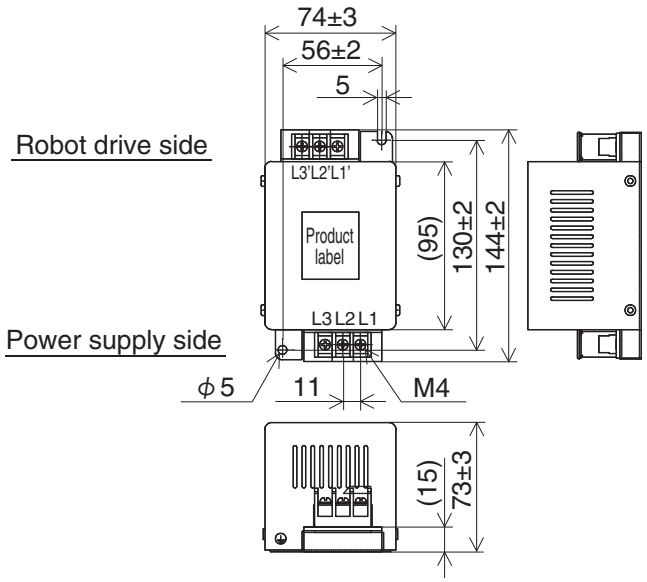
■ Model No

NF – CEH 7
- 7: Rated current of noise filter
- CEH: EMC compliance
- NF: Series name (NF series)

■ Connection diagram (3-phase filter)



■ Dimensions (mm)

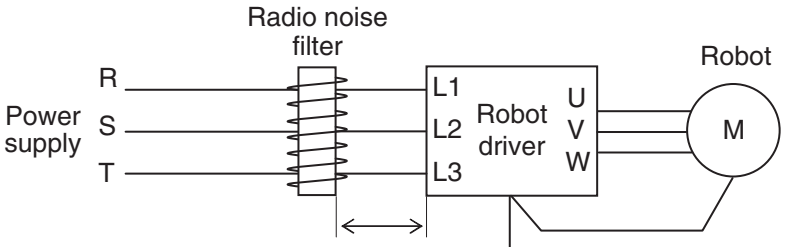


■ Specifications

Robot driver model No.	Noise filter model No.	Rated voltage	Rated current	Mass (kg)
RD*-05	NF-CEH7	480V AC	7A	0.7
RD*-10				
RD*-20				
RDP-25				

(5)Radio noise filter (zero-phase reactor)

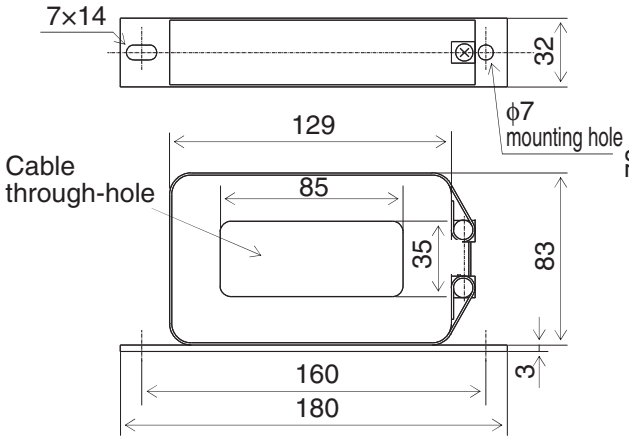
■ **Connection diagram**



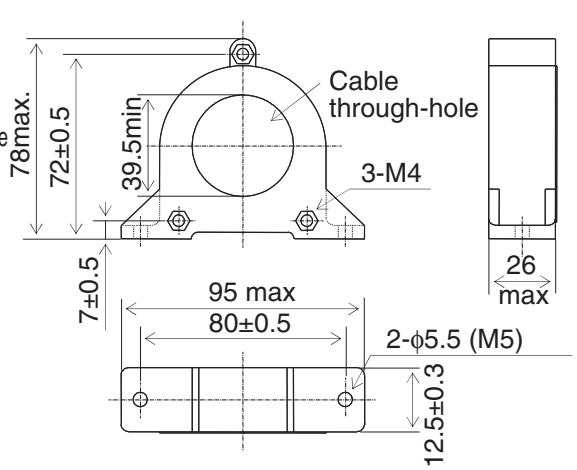
Note 1: Wind 3-phase wires L1, L2 and L3 in the same direction.
Note 2: This filter can be used on both input and output sides of robot driver.

■ **Dimensions (mm)**

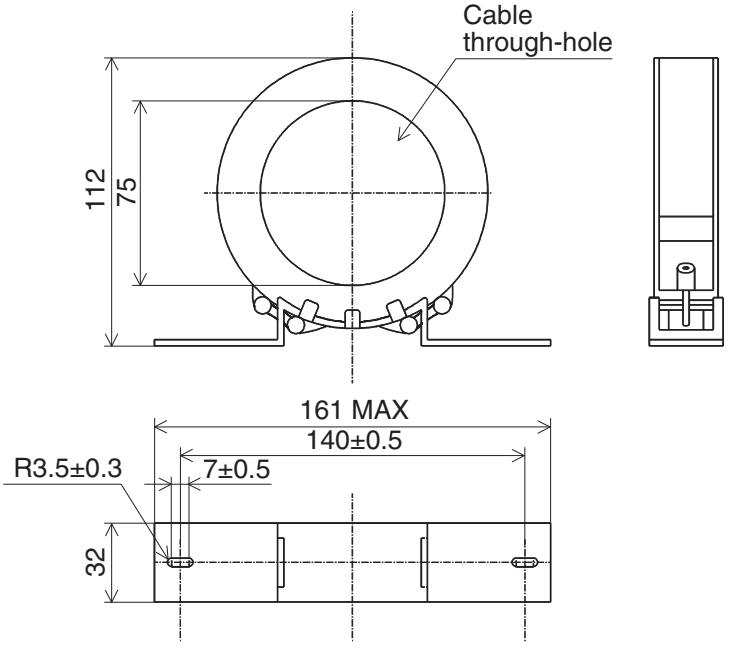
ZCL–A



ZCL–B40



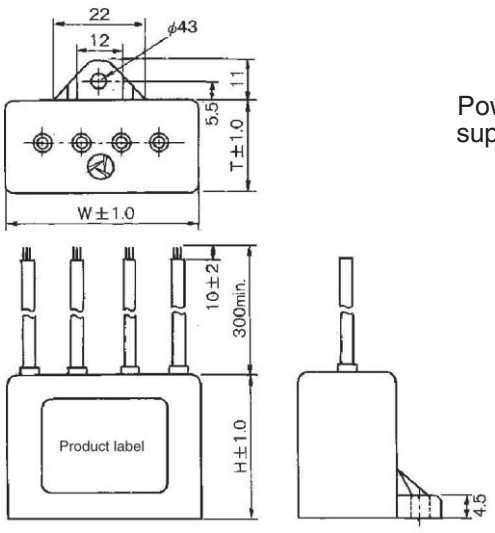
ZCL–B75



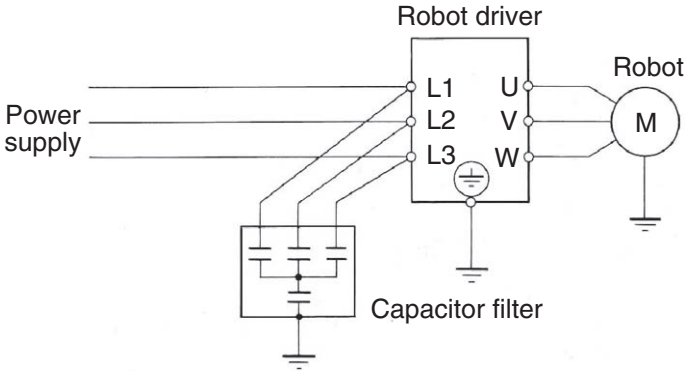
(6)Input-side radio noise filter (capacitor filter)

Connect this filter directly to the power terminals on the robot driver to reduce radiation noise emitted from the cable.

■ **Dimensions (mm)**

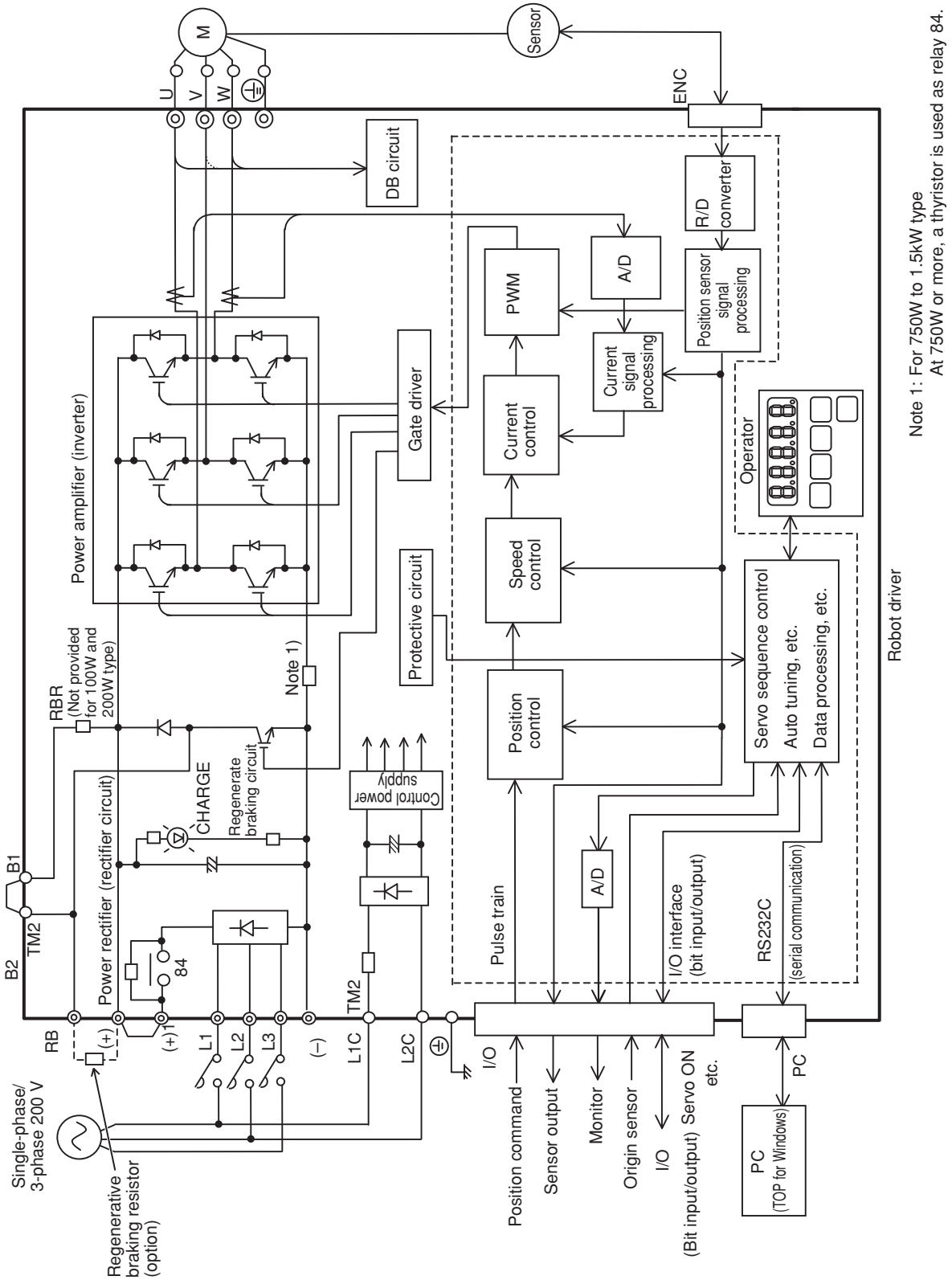


■ **Connection diagram**



Model No.	W	H	T
CFI-L (250V rating)	48.0	35.0	26.0

10.4 Internal block diagram of robot driver



Note 1: For 750W to 1.5kW type
At 750W or more, a thyristor is used as relay 84.

Revision record

Manual version	Issue date	Description
Ver. 2.00	Dec. 2009	Addition of RDP-25 and applicable robot type. Addition and correction of reference graph for setting the position control cut-off frequency. Modification in "5.17 Magnetic pole position estimation action". The address and other information were added to the front cover.
Ver. 2.01	Mar. 2010	Addition of parameter (Fd-44) and modification in other parameters in accordance with the addition.
Ver. 2.02	Aug. 2010	Addition of reference graph for setting the acceleration and position control cut-off frequency in accordance with addition of applicable robot (MF7). Modification of serial number label. Addition of "4.3 Emergency stop", etc.
Ver. 2.03	Jan. 2011	The description regarding "Warranty" was changed, etc.
Ver. 2.04	May 2011	Correction of reference graph for setting the acceleration and position control cut-off frequency. Clerical error corrections.
Ver. 2.05	Dec. 2011	The timing chart regarding servo-on was added. The description regarding error codes (E09 and E95) was added and corrected. The cautions on regenerative braking resistor were added. “10.1 Timing chart” was added, etc.

User's Manual

YAMAHA Robot Driver **RD series**

Dec. 2011
Ver. 2.05
This manual is based on Ver. 2.05 of Japanese manual.

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IM Operations

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